

OPERATOR'S MANUAL

No. AS-104

**STANDARD 1600-HP. ALL-SERVICE
DIESEL-ELECTRIC LOCOMOTIVES**



**BALDWIN-LIMA-HAMILTON CORPORATION
PHILADELPHIA, PA.**

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STANDARD 1600-HP. ALL-SERVICE DIESEL-ELECTRIC LOCOMOTIVES

WITH ELECTRIC THROTTLE and 6-SL BRAKE EQUIPMENT

Plus Modifications, Such As

MULTIPLE UNIT CONTROL

DYNAMIC BRAKING

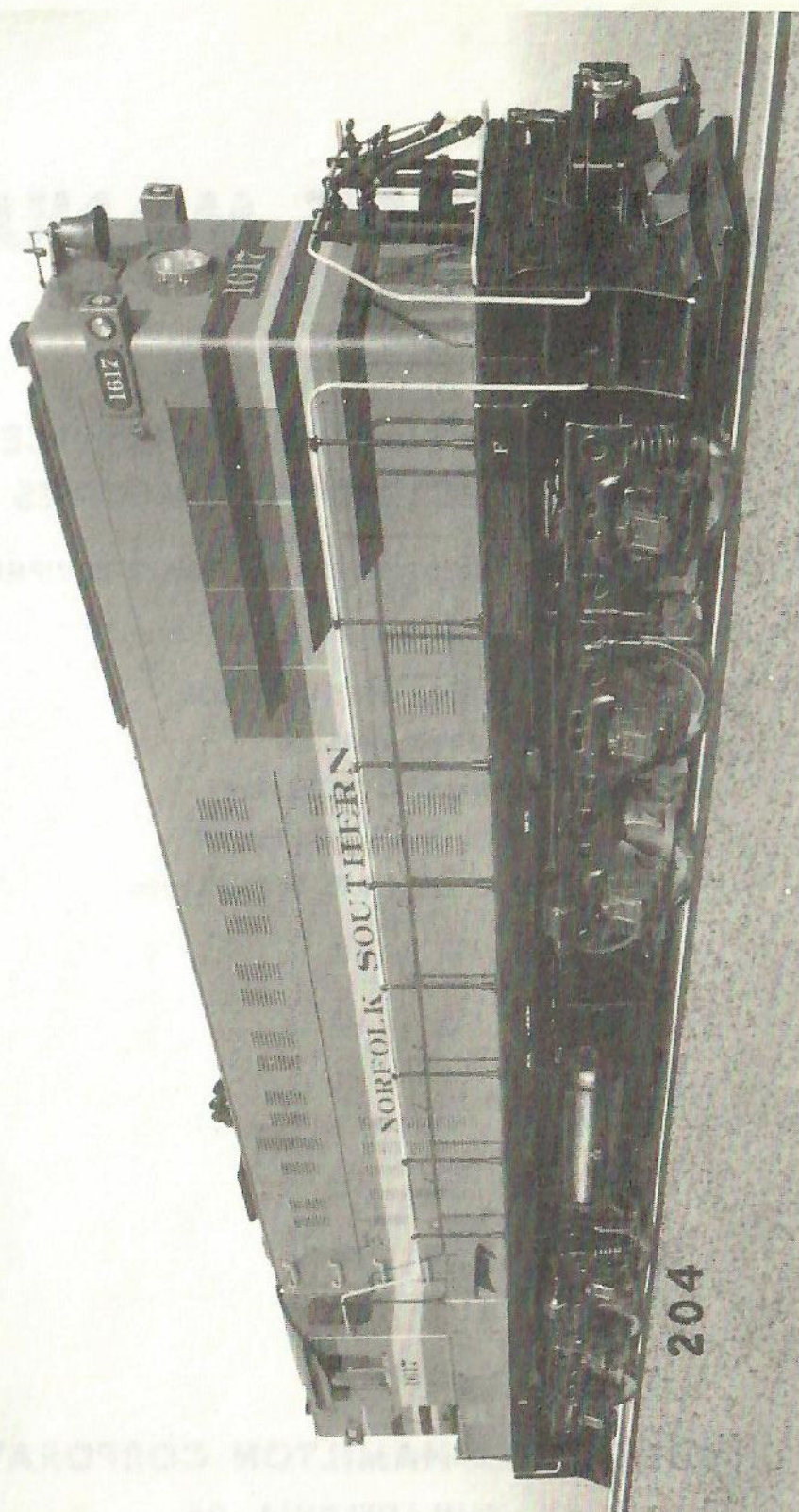
PNEUMATIC THROTTLE

24-RL BRAKE EQUIPMENT

DUAL CONTROL STANDS, etc.

**BALDWIN-LIMA-HAMILTON CORPORATION
PHILADELPHIA, PA.**

10-1-55



1600-HP., ALL-SERVICE LOCOMOTIVE (AS-416) — FIGURE 1

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1600-HP. ALL-SERVICE
LOCOMOTIVE

GENERAL SPECIFICATIONS

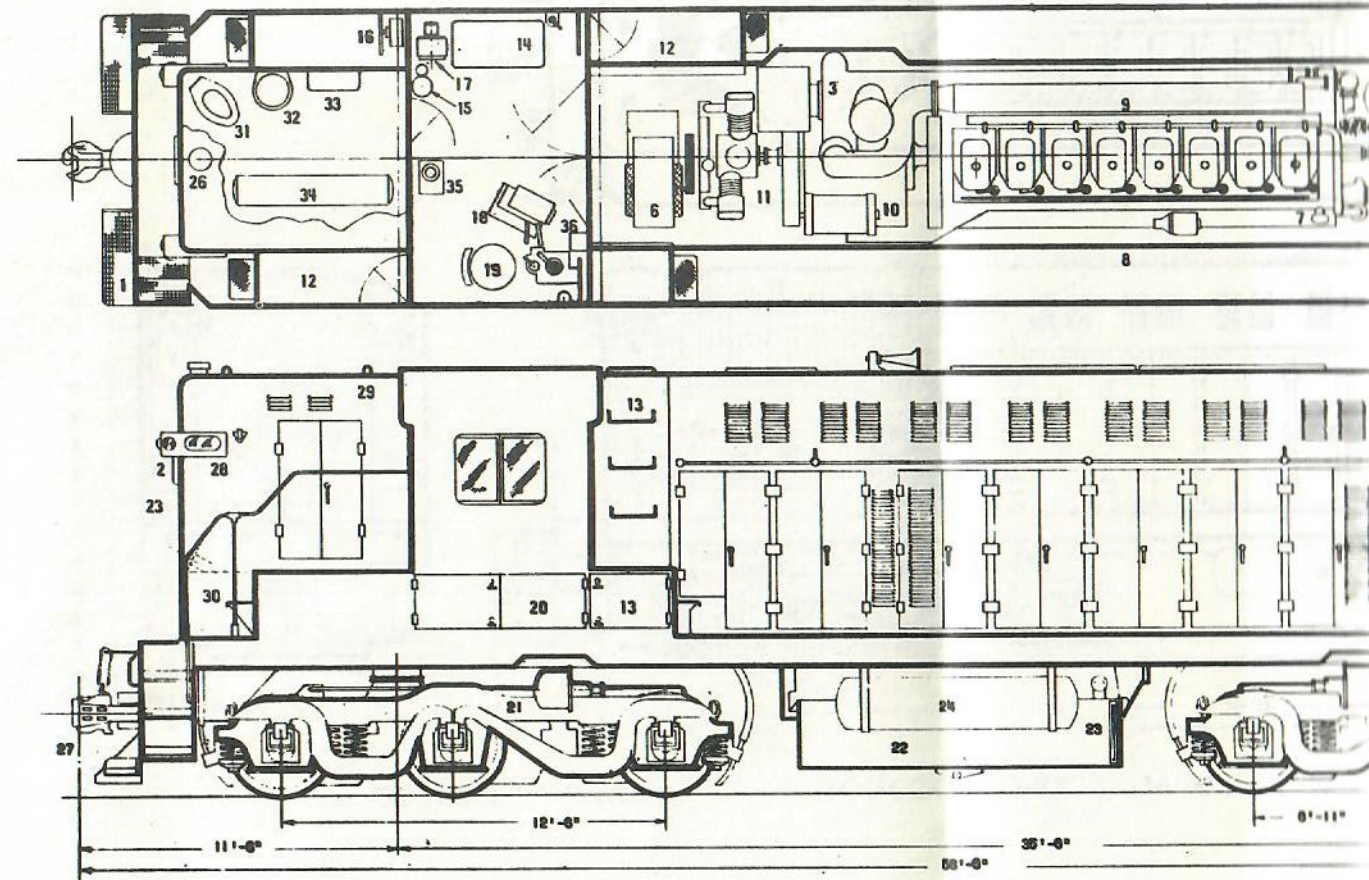
B.L.W. Classification	AS-16	AS-416	AS-616
Wheel Arrangement	0-4-4-0	0-6-6-0	0-6-6-0
Wheel Diameter	40"	42"	40"
Driving Motors	4	4	6
Gear Ratio	18:74 18:65 19:64	18:74 — —	18:74 — —
Max. Speed—MPH (18:74 Gear Ratio)	65	65	60
Max. Speed—MPH (18:65 Gear Ratio)	75	—	—
Max. Speed—MPH (19:64 Gear Ratio)	80	—	—
Total Approx. Wgt. Lb., in Working Order	242,000	258,000	325,000
Diesel Engine (One) Supercharged	8 Cylinder	8 Cylinder	8 Cylinder
Fuel Oil Tank, Gal. Capacity	900	900	1900
Lubricating Oil Capacity	185 Gal.		
Cooling Water Capacity	300 Gal.		
Sand Capacity	30 Cu. Ft.		

GENERAL DESCRIPTION

The following operating instructions apply to standard 1600-hp all-service locomotives. These locomotives are designed for flexible operation in either general switching or road service. The standard 4-motor or 6-motor single unit locomotives may be obtained with modifications which permit multiple unit operation or dynamic braking. Such equipment is an addition to the locomotive, and normal operation of multiple unit locomotives as a single unit, or of dynamically braked locomotives in motoring, remains unchanged except to check that certain items are properly set. Such equipment is generally designated "if installed," and its absence on any locomotive in no way affects the suitability of the remaining instructions. Other modifications, such as 24-RL brake equipment, and dual control stands, require revision instead of addition to the instructions, and such operating instructions are described in separate paragraphs.

Crews should be familiar with the cab and equipment cabinet which are described on the pages immediately following. They should also be familiar with the fan control switch, and with various protective devices located elsewhere on the locomotive, such as circuit breakers, the overspeed stop, the emergency fuel cut-off valve, engine shut-down valve, ground relay, etc., and the related alarm system. Location of principal items outside the cab and cabinet are shown in Figures 2 and 3, and the description thereof may be found by reference to the index.

An eight cylinder, supercharged diesel engine drives a direct connected main generator which delivers electric power to traction motors geared to the driving axles. Automatic load regulation is provided by equipment in the excitation circuit which automatically varies the field current to obtain suitable generator output. The system protects the diesel engine from overload, and assures maximum smooth acceleration and full engine power output throughout the normal operating range. This automatic determination of

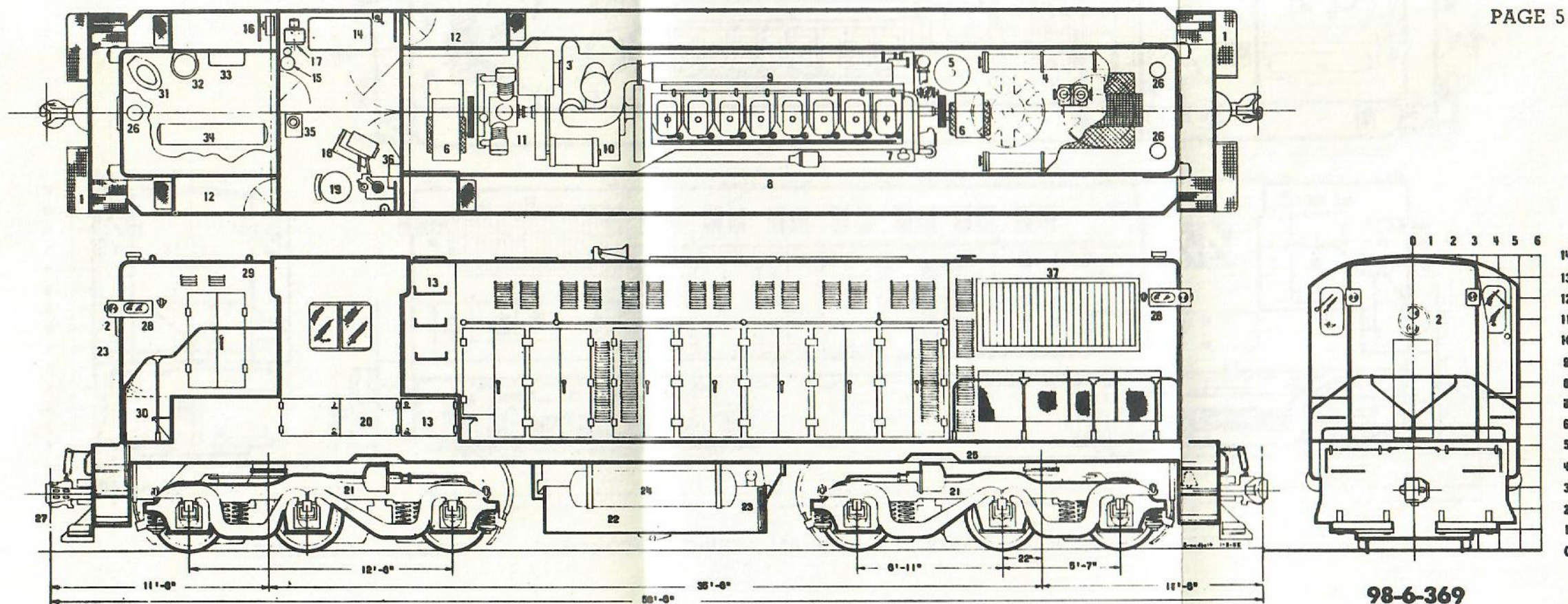


LOCATION OF PRINCIPAL PARTS

FIGURE 2

1. SWITCHMEN'S STEPS
2. HEADLIGHT
3. SUPERCHARGER
4. COOLING SYSTEM, RADIATOR CORES, FAN AND DRIVE
5. LUBE OIL FILTER
6. TRACTION MOTOR BLOWER
7. LUBE OIL FILLER
8. ENGINE COMPARTMENT
9. DIESEL ENGINE
10. MAIN GENERATOR
11. AIR COMPRESSOR
12. STORAGE BATTERIES

13. ELECTRICAL EQUIPMENT CABINET
- *14. HELPER'S SEAT
15. FIRE EXTINGUISHER
16. HANDBRAKE
17. CAB HEATER
18. OPERATOR'S CONTROLS
19. OPERATOR'S SEAT
20. AIR BRAKE EQUIPMENT
21. MOTOR TRUCK
22. FUEL OIL TANK
23. FUEL OIL TANK FILLER
24. AIR RESERVOIR
25. WATER FILLER, DIESEL ENGINE



LOCATION OF PRINCIPAL PARTS

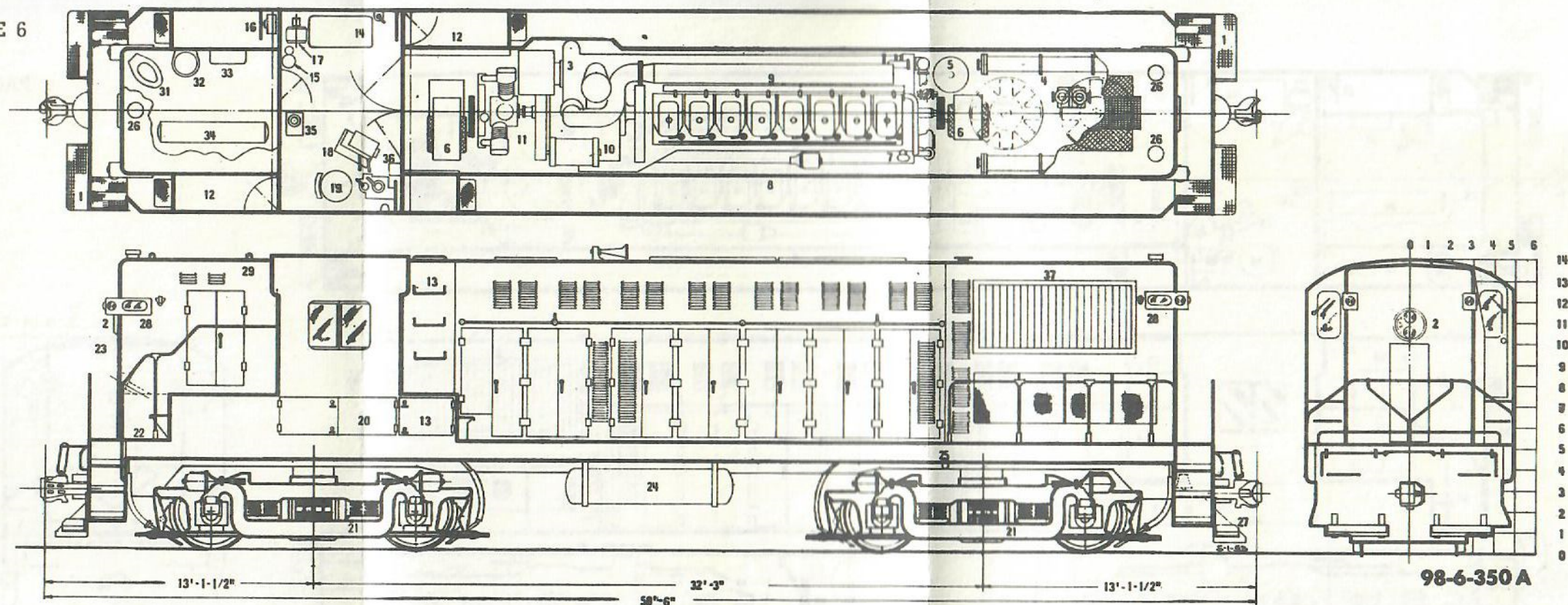
FIGURE 2

- | | | |
|--|----------------------------------|----------------------------------|
| 1. SWITCHMEN'S STEPS | 13. ELECTRICAL EQUIPMENT CABINET | 26. SAND BOX FILLER |
| 2. HEADLIGHT | *14. HELPER'S SEAT | 27. PILOT |
| 3. SUPERCHARGER | 15. FIRE EXTINGUISHER | 28. MARKER AND NUMBER LIGHT |
| 4. COOLING SYSTEM, RADIATOR CORES, FAN AND DRIVE | 16. HANDBRAKE | 29. REAR COMPARTMENT |
| 5. LUBE OIL FILTER | 17. CAB HEATER | 30. WATER TANK OR AUX. FUEL TANK |
| 6. TRACTION MOTOR BLOWER | 18. OPERATOR'S CONTROLS | *31. TOILET |
| 7. LUBE OIL FILLER | 19. OPERATOR'S SEAT | *32. WASH STAND |
| 8. ENGINE COMPARTMENT | 20. AIR BRAKE EQUIPMENT | *33. CLOTHES LOCKER |
| 9. DIESEL ENGINE | 21. MOTOR TRUCK | *34. TOILET WATER TANK |
| 10. MAIN GENERATOR | 22. FUEL OIL TANK | *35. WATER COOLER |
| 11. AIR COMPRESSOR | 23. FUEL OIL TANK FILLER | *36. SPEED RECORDER |
| 12. STORAGE BATTERIES | 24. AIR RESERVOIR | *37. DYNAMIC BRAKE RESISTOR |
| | 25. WATER FILLER, DIESEL ENGINE | *Modification (if installed) |

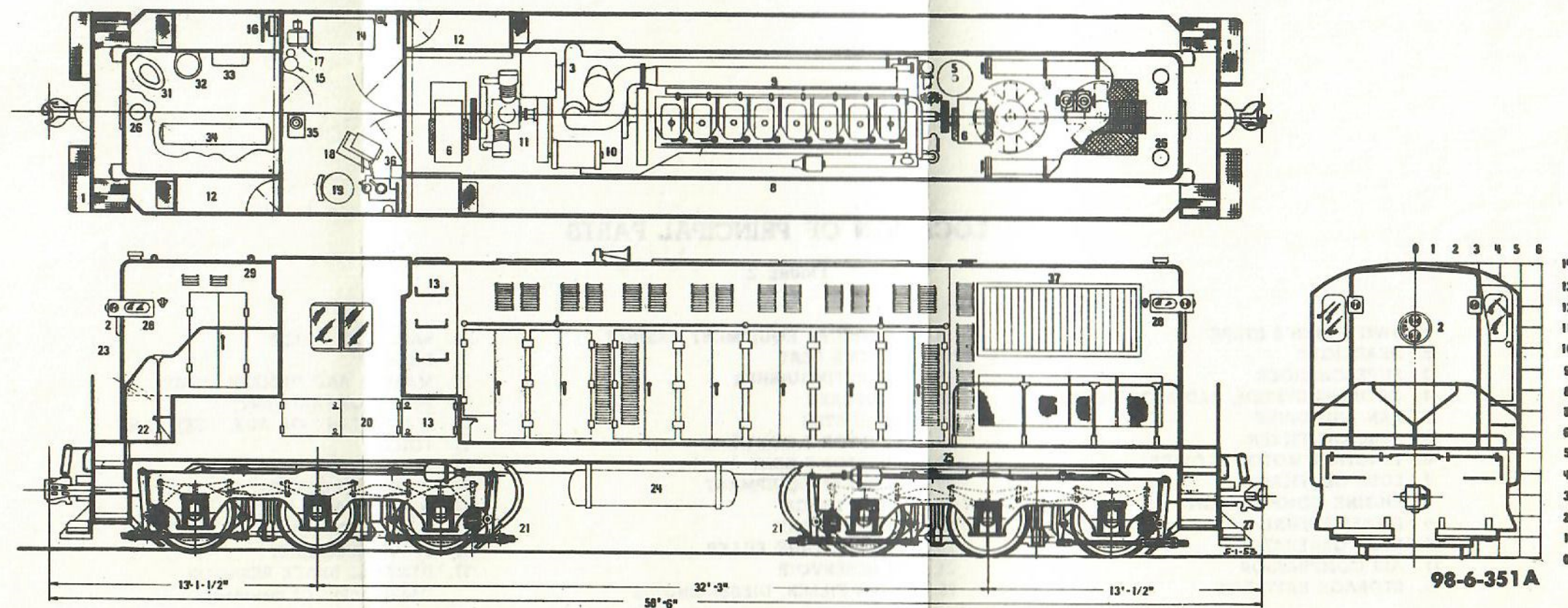
AS-616 ALL SERVICE LOCOMOTIVE

1600 H.P. AVAILABLE FOR TRACTION

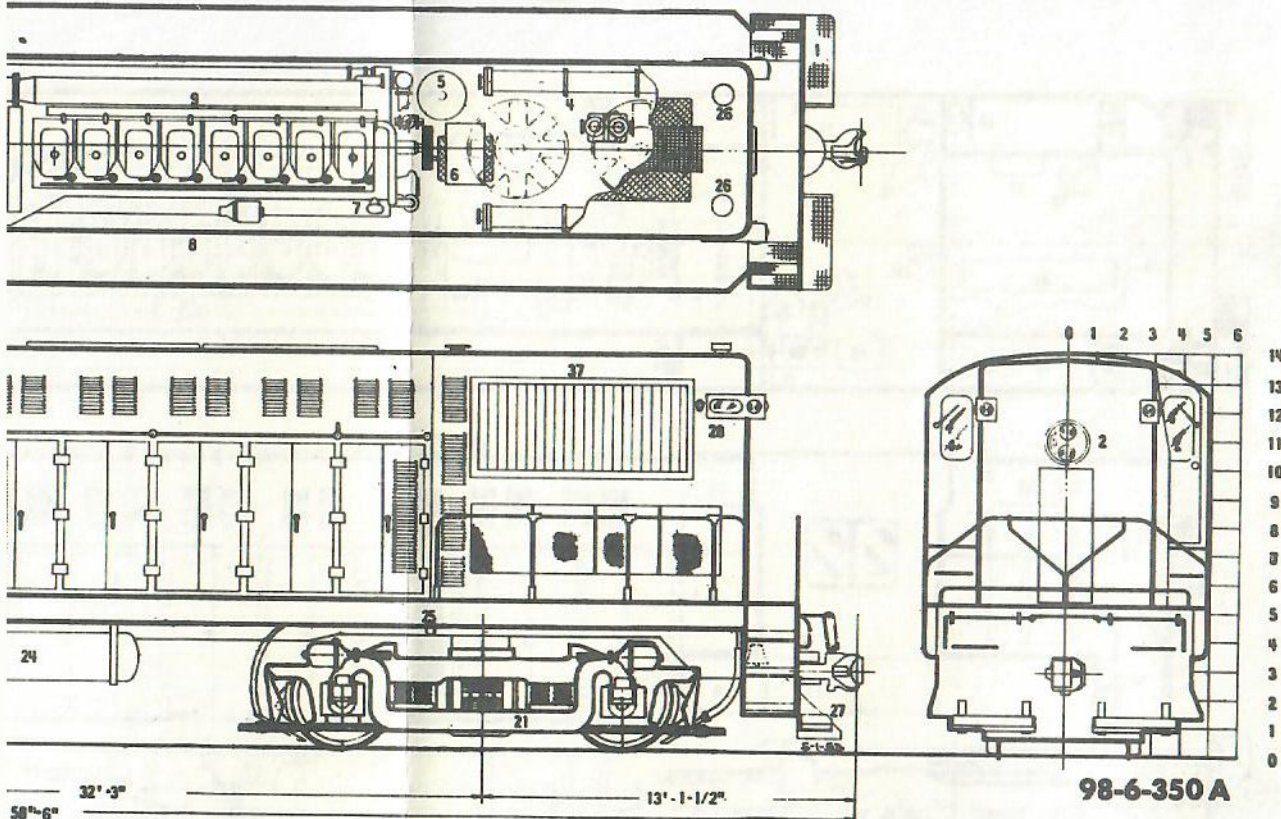
6 AXLES—6 MOTORS



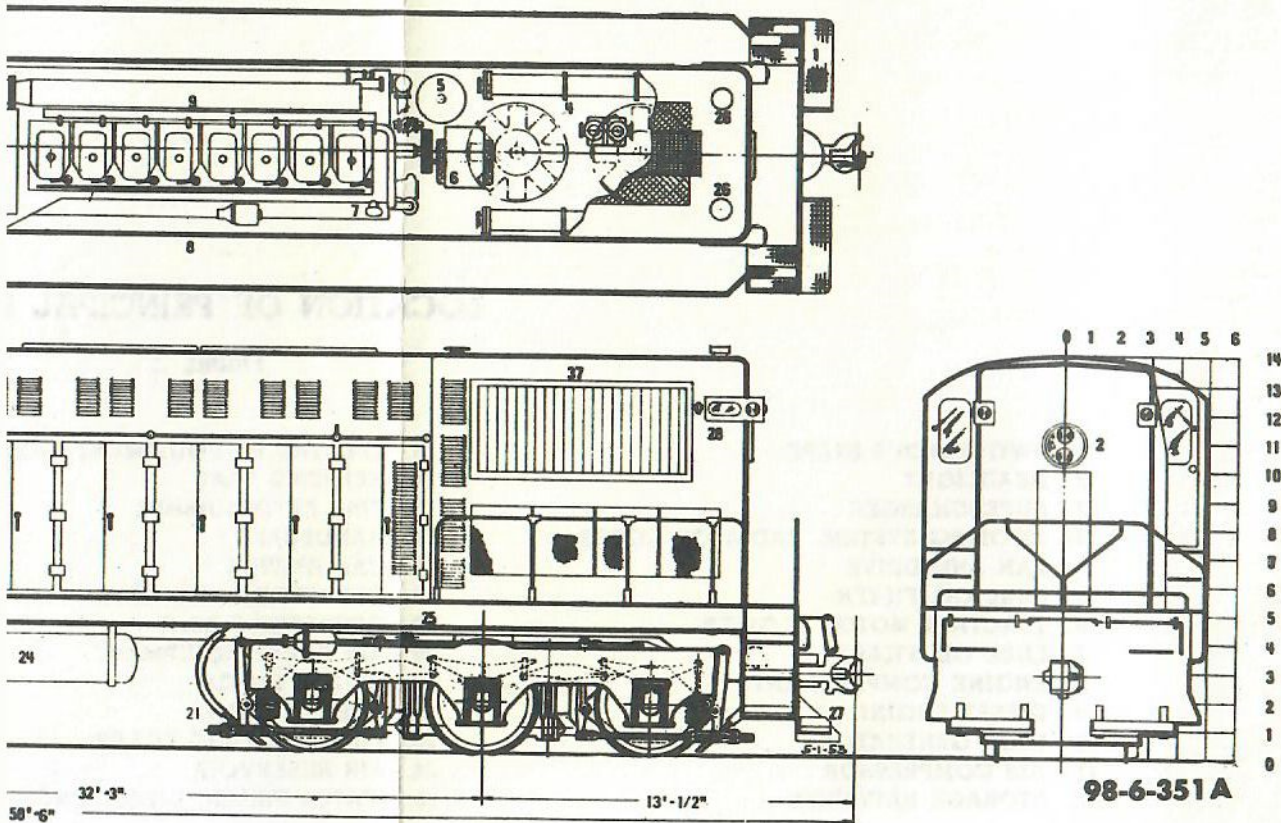
LOCATION OF PRINCIPAL PARTS AS-16 ALL SERVICE LOCOMOTIVE 4 AXLES — 4 MOTORS



LOCATION OF PRINCIPAL PARTS AS-416 ALL SERVICE LOCOMOTIVE 6 AXLES — 4 MOTORS



AS-16 ALL SERVICE LOCOMOTIVE 4 AXLES — 4 MOTORS



AS-416 ALL SERVICE LOCOMOTIVE 6 AXLES — 4 MOTORS

FIGURE 3

available power does not require judgment by the engineer. The throttle controls speed and power with maximum simplicity, leaving the engineer free to handle other controls and observe gauges, signals and road conditions.

An auxiliary generator charges the battery, and energizes the control circuits. The battery starts the engine and provides standby lighting service. The engine is started from the cab by pressing the start buttons which control the starting circuit, connecting the battery at the main generator which acts as a motor while cranking the engine. Traction motor blowers are engine driven; radiator fans are motor driven.

Air for the brakes is supplied from a main reservoir at a pressure of 125 lb. to 140 lb. Air is pumped into the reservoir by a two-stage compressor which operates whenever the diesel engine runs. A compressor governor, connected to the main reservoir, determines whether or not the compressor is actually pumping air into the high pressure lines. A governor cut-out is set to prevent pressure in excess of 140 lb., and to resume pumping when pressure drops to 125 lb. A pneumatic control system operating in conjunction with the throttle and electrical equipment, functions at a pressure of 70 psi. It will require no attention during normal operation if the gauges indicate the proper reading.

Crews who are not familiar with multiple unit operation should carefully observe the distinction between double heading and multiple unit operation when reading or applying these instructions. In multiple unit operation, locomotives of the same type are connected electrically in addition to the coupling of the draw bar and air lines, and one locomotive controls all units. In double heading, locomotives which are not similar may be coupled, and are controlled independently except the brakes which are handled by the designated lead locomotive.

LOCOMOTIVE CAB

Controls and instruments necessary for routine operation of the locomotive are conveniently located in front of the engineer. A thorough knowledge of the engineer's equipment in the accompanying illustrations will enable the operator to understand various modifications which may be encountered on specially equipped individual locomotives.

Throttle

The throttle acts on the governor to control engine speed and power output. The standard throttle is an electric throttle with an Engine Stop position, Idle position, and eight running positions numbered from 1 to 8. An indicator in the casing shows what position it is in. A pneumatic throttle may be installed when a locomotive is to be used with another locomotive having a pneumatic throttle. Both types of throttle regulate the position of the fuel shaft on the engine through a governor which is connected electrically or pneumatically to the throttle. An electric throttle functions through solenoids built into the governor, and a pneumatic throttle functions through an actuator. The electric throttle is usually advanced (opened) one notch at a time. The pneumatic throttle moves smoothly through its range and is advanced slowly to any desired position.

Reverse Lever

The reverse lever controls the direction of travel, and is interlocked with the throttle so that it cannot be moved except when the throttle is off. It has three positions, Forward, Reverse and Off. An additional braking position is provided on locomotives equipped for dynamic braking.

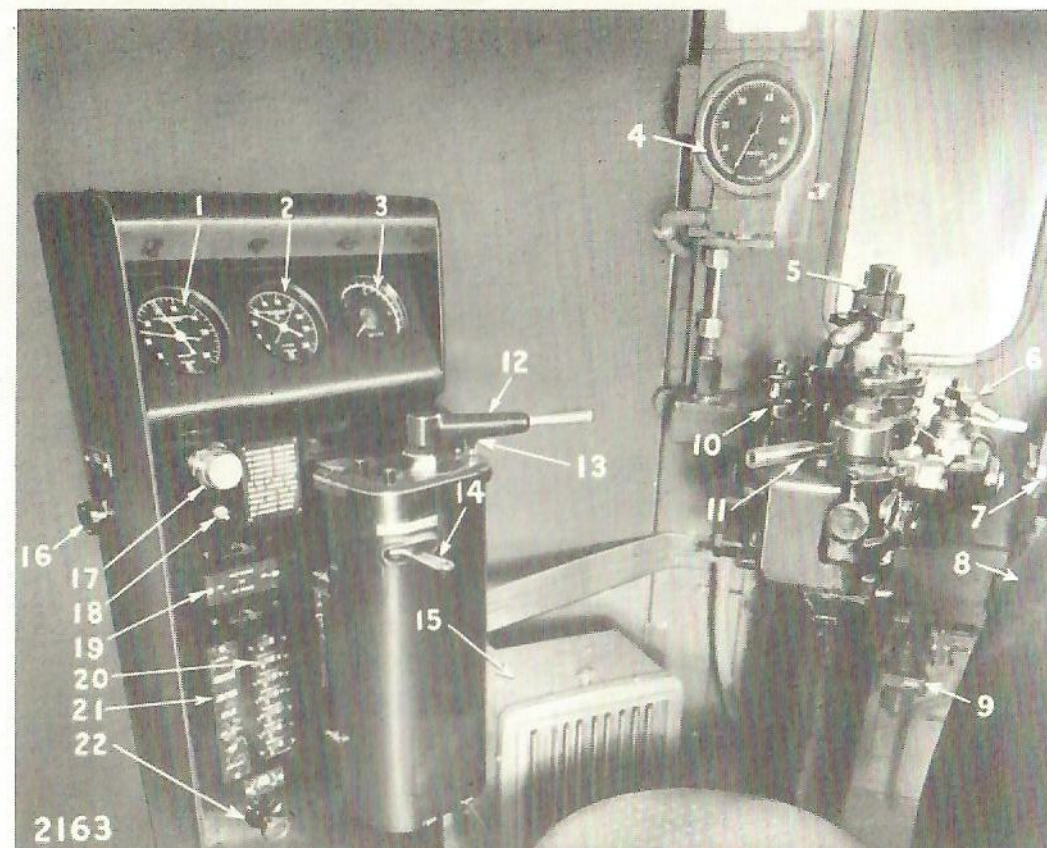
Load Ammeter

This ammeter indicates the amount of current flowing through the traction motors. The readings of this meter must be kept within allowable load limits (page 19).

Brake Equipment

Standard 6-SL brake equipment is mounted on the brake pedestal, unless otherwise stated in these instructions.

ENGINEER'S POSITION IN CAB



MANUAL CONTROLS

Typical 17KC91H Control Stand with 6-SL Brake Equipment

FIGURE 4

- | | |
|---|---|
| 1. BRAKE PIPE AND CYLINDER PRESSURE GAUGE | 12. ALARM BELL AND WHEEL SLIP BUZZER (on Side of Control Stand) |
| 2. MAIN AND EQUALIZING RESERVOIR PRESSURE GAUGE | 13. THROTTLE |
| 3. LOAD AMMETER | 14. REVERSER LEVER |
| 4. SPEED RECORDER | 15. CAB HEATER |
| 5. AUTOMATIC BRAKE VALVE HANDLE | 16. HEATER RHEOSTAT AND SWITCH |
| 6. BELL RINGER | 17. TRAIN ORDER LIGHT |
| 7. HORN VALVE | 18. TRAIN ORDER LIGHT SWITCH |
| 8. WINDSHIELD WIPER VALVE | 19. HEADLIGHT SWITCHES |
| 9. CONTROL AIR VALVE | 20. CONTROL SWITCH |
| 10. SANDER VALVE | 21. LIGHTING SWITCH |
| 11. INDEPENDENT BRAKE VALVE HANDLE | 22. CONTROL STAND LIGHTS DIMMING RHEOSTATS |

Refer to Figure 6 (view of cabinet from cab) Items 1 to 11 for location of Engine Switches and Gauges, M. U. Switches, Ground Relay Light and Switch. These items are located at top of Electrical Equipment Cabinet, inside of cab.

ENGINEER'S POSITION IN CAB

Gauges are located on the control stand, or the control panel on the front wall of the cab.

Nameplates identify the various electrical switches in the cab. The function of the lighting switches is obvious, and the use of other switches is clearly set forth in the operating instructions. Briefly, these switches are provided for the following purposes.

Control Switch

This is the master switch to the control circuits, and must be closed to start the diesel engines or operate the locomotive. On locomotives connected for multiple unit operation, the control wire is train-lined to all units, and only the leading or controlling unit should have its control switch closed.

Auxiliary Generator Field Switch

This switch must be closed to excite the fields and charge the battery. This 15-amp switch in the cab is separate from the 200-amp Auxiliary Generator Power Switch in the cabinet, which is normally closed.

Fan Control Switch

This switch feeds the fan control circuit. It is normally in the automatic position. See further details under "Cooling Water System."

Engine Control Switch

It is fed through the Control Switch, and enables the operator to idle or stop an engine without cutting out the locomotive control circuits. It must be closed to run the diesel engine on any unit so equipped. Locomotives in multiple may be controlled from the cab of a leading unit which is idled or stopped by the engine control switch.

Ground Relay Reset Button

Cuts out ground relay. See detailed description of its function (page 25).

Circuit Breakers

Breaker type switches are used to protect various electrical circuits, thereby eliminating fuses. These switches open automatically when overloaded, and are closed manually. After opening, they must be moved to the full "off" position before being reclosed. The Control Switch, the Auxiliary Generator Field Switch and all lighting switches except the headlight switch are breakers.

Alarm System

All indicator lights and audible alarms should be thoroughly understood. The wheel slip buzzer is independent of any other alarm. The alarm bell may be connected to several protective devices, in which case indicator lights will generally show the nature of the trouble. The ground relay in many cases lights a light without ringing the bell. On multiple unit locomotives, the ground relay, water temperature switch, and engine shut-down (low lube oil pressure switch) are also connected to the alarm bells, which will ring in all units, but indicator lights, if any, will burn only in the faulty unit. Frequently a light is not provided if the protective device shuts down or idles the engine, because that in itself is an indication. In dynamic braking, additional lights may be installed, as described thereunder.

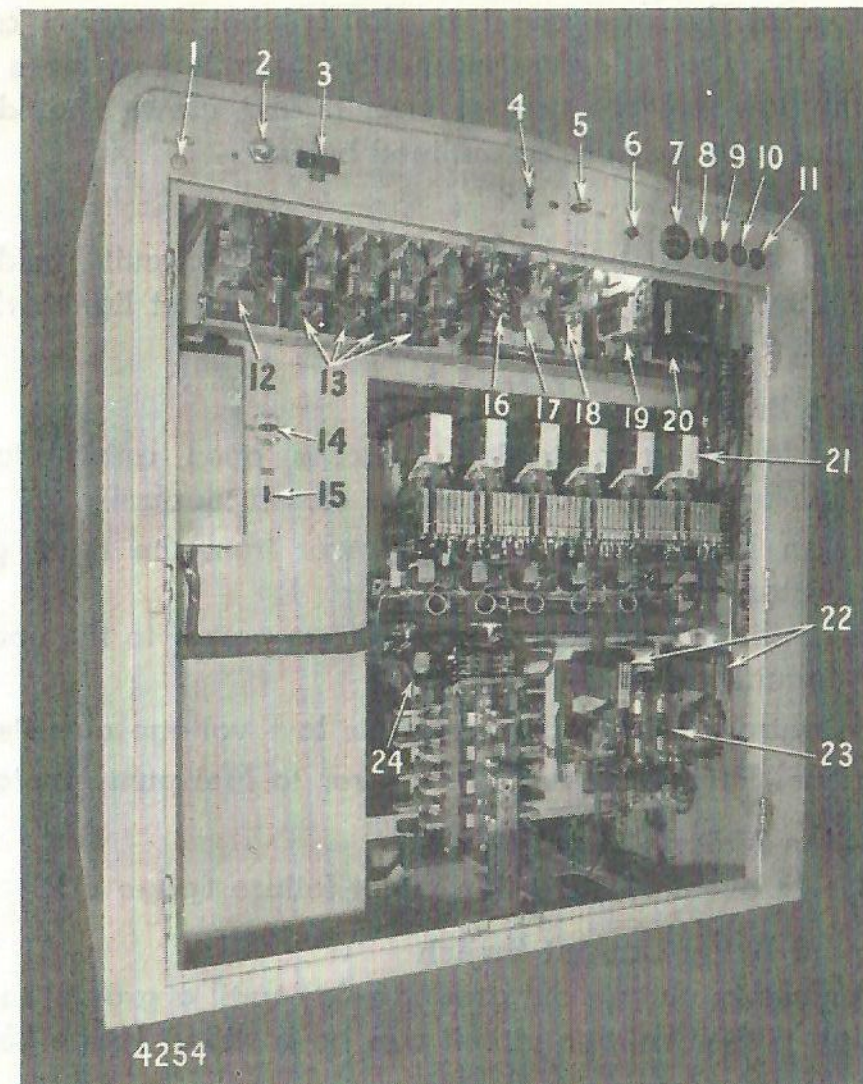
Heater Rheostats

Controls variable-speed fans in cab heaters.

ELECTRICAL EQUIPMENT CABINET

SAFETY NOTE: The main power circuits operate at 600 volts or more. Cabinet doors should not be opened except by authorized and qualified personnel. When doors are open, it is important that adequate safety rules be observed.

Most of the electrical equipment is located in a cabinet situated between the cab and the diesel engine. This equipment as viewed from the cab is shown on the opposite page.



Typical Electrical Equipment Cabinet

FIGURE 6

- | | |
|-----------------------------------|-------------------------------------|
| 1. GROUND RELAY RESET BUTTON | 13. FIELD SHUNTING CONTACTORS |
| 2. GROUND LIGHT | 14. TRACTION MOTOR CUT-OUT SWITCH |
| 3. GROUND RELAY CUT-OUT SWITCH | 15. RADIATOR FAN SWITCH |
| 4. MULTIPLE UNIT SWITCH | 16. GENERATOR FIELD CONTACTOR |
| 5. ENGINE CONTROL SWITCH | 17. FUEL PUMP CONTACTOR |
| 6. ENGINE START BUTTON | 18. RADIATOR FAN SHUNTING CONTACTOR |
| 7. BATTERY CHARGING AMMETER | 19. RADIATOR FAN POWER CONTACTOR |
| 8. FUEL OIL PRESSURE GAUGE | 20. RADIATOR FAN CIRCUIT BREAKER |
| 9. ENGINE LUBE OIL PRESSURE GAUGE | 21. POWER SWITCHES |
| 10. TURBO LUBE OIL PRESSURE GAUGE | 22. STARTING CONTACTORS |
| 11. WATER TEMPERATURE GAUGE | 23. BATTERY SWITCH |
| 12. REVERSE CURRENT CONTACTOR | 24. REVERSER |

Most of the equipment in the cabinet functions automatically. The following manually controlled switches are in the low voltage control circuit, and crews should be familiar with their use as outlined below.

Battery Switch

Must be closed to energize all control circuits, and all lighting circuits except the cab and cabinet lights which are fed directly from the battery.

Circuit Breakers

The following protective switches open automatically when overloaded, and must be closed manually.

Fan Motor—high voltage power from the main generator.

Auxiliary Generator—low voltage power to the control circuits, lights and battery.

Control and Lighting—various low voltage circuits.

Fuel Pump—low voltage power to fuel pump motor.

Traction Motor Cut-out Switches

Use in event of a traction motor failure (page 21).

Ground Relay Cut-out Switch

For use in cutting out ground relay until a ground in the high power voltage circuit can be rectified (page 25).

Multiple Unit Switch

Installed only with pneumatic throttle. It is utilized for transferring control to opposite end when two or more locomotives are being operated as a single unit (pages 29-32).

It is important that operators do not attempt to adjust or repair the voltage regulator or change relay settings.

The principal items of electrical control equipment not mounted in the electrical cabinet are: engine shut-down valve, lube oil pressure switch, hot water switch (if installed), temperature control switches and shutter valve, if installed. Consult "Arrangement of Equipment" diagram, Figure 2 for location of these items.

LOCOMOTIVE OPERATION

SUMMARY OF NORMAL OPERATION

I. To Start Diesel Engine:

- A. The battery switch and fuel pump switch must be closed.
- B. The control switch must be closed. (In multiple unit operation, close leading unit only.)
- C. Check that engine control switch and multiple unit switch are in correct position.
- D. Check that throttle and reverse lever are off.
- E. Press start button firmly. (Do not drain battery if engine does not turn.)

II. To Move Locomotive:

- A. Check air pressure and perform brake test.
- B. Move reverse lever to desired direction.
- C. Release brakes.
- D. Advance throttle (slowly).

III. Miscellaneous:

- A. Comply with ammeter indications.
- B. Come to full stop before reversing.
- C. Reverse lever is interlocked so it cannot be moved except when throttle is off.
- D. Check gauge readings.
- E. When stopping, retard throttle before applying brakes, to avoid electrical overload.

IV. To Shutdown Locomotive:

- A. Open control switch. This stops the engine.
- B. Open battery switch.
- C. Set hand brake. Remove reverse lever and brake handles.

DETAILS OF OPERATION

Normal operating procedures for standard all-service locomotives for single unit operation, or with additional equipment for multiple unit operation or dynamic braking, are almost identical with each other. The following information applies to all such locomotives unless otherwise designated. Separate paragraphs are devoted to special modifications in equipment, and to specific details of multiple unit operation and dynamic braking.

I. Preliminary:

A. Check the following supplies:

1. Fuel oil.
2. Engine crankcase oil.
3. Air compressor crankcase oil.
4. Engine governor oil.
5. Engine cooling water.
6. Sand.

B. Check for any leaks in fuel, water and lubricating oil piping. Leaks are more probable on a warm engine under normal pressure, and any leaks observed under such conditions should be reported.

C. Turn on lights, if necessary. On most locomotives, no lights but the cab lights will burn until the battery switch in the equipment cabinet is closed.

D. Inspect the engine, generator and other machinery for rags, tools, etc., that may have been accidentally left near moving parts.

II. Starting the Diesel Engine:

A. Close the battery switch in the cabinet. While cabinet doors are open, check that circuit breakers are closed (Auxiliary Generator Power, Auxiliary

Generator Field, Fan, Fuel Pump, and Control-Lighting Breakers), check that Traction Motor Cut-out Switch, Ground Relay Cut-out Switch, etc., are set properly.

B. If equipped for multiple unit operation, the Engine Control Switch should be in No. 2 position, and the multiple unit switch should be in single unit position "S" when operating alone, or in lead.

C. Insert reverse lever. Leave it in the "off" position.

D. Check that throttle is off.

E. Close the control switch on control stand. The fuel supply pump should start, and a pressure of 25 lbs. minimum should be indicated on the fuel oil pressure gauges. If pump runs and no pressure is indicated, check fuel supply or emergency fuel cut-off valve at the fuel tank and reset if necessary. The control switch is not closed in trailing units.

F. Press "engine start" button. Press firmly until the engine fires. If engine does not fire, do not hold button in for prolonged periods because continued cranking will run down the battery. If the engine does not rotate, release button immediately.

G. Let the engine idle until the water temperature reaches 120° F.

III. Pumping Air:

A. As the engine runs, the air compressor will pump air into the main reservoirs. Check the main reservoir air pressure to be sure the compressor stops pumping when the governor cut-out setting of 140 lb. is reached.

- B. Air may be pumped at a higher rate with the locomotive at standstill (initially charging the line), or while coasting downgrade with a train. Bring the engine speed above idling as follows:
 1. Leave the reverse lever in the "off" position.
 2. Increase the throttle setting, speeding up the engine and the compressor, until the pumping rate desired is reached.
 3. Return the throttle to the "off" position when air pressure gauge registers required pressure.
- C. Be sure the air compressor resumes pumping when the main reservoir pressure drops to the lower governor setting of 125 lb.
- D. Check the control air pressure gauge. It should read 70 lb.

IV. Moving the Locomotive:

- A. With the engine running and the throttle and reverse lever off, make sure that:
 1. The automatic and independent air brakes apply and release properly. Release hand brake.
 2. The traction motor blowers are operating properly.
 3. The radiator fans are operating. They are electrically driven. The fan switch should be in "auto" position. (See Cooling System for non-automatic operation.)
- B. Move the reverse lever to the "forward" or "reverse" position according to the direction the locomotive is to travel.
- C. Release brakes and advance the throttle slowly until current is indicated on the load ammeter. If the train is not too heavy nor the grade severe, the locomotive will move. If the locomotive does not move, return the throttle to the "off" position immediately.

- D. When the meter registers current and the train starts to move, slowly move the throttle to the position required for the train acceleration desired. As train speed increases the traction motor transition fields are automatically weakened by shunting the field windings with resistance, rendering it possible to run at higher speeds. Amperage increases at time of shunting.
- E. The throttle should be moved slowly to prevent the wheels from slipping. If the wheels should slip, the wheel slip buzzer will sound and field excitation will be reduced automatically to reduce power until slipping stops. If wheels slip again, retard the throttle until wheel slip stops. Do not use sand. See next paragraph.

V. Sanding:

Do not Apply Sand While the Wheels are Slipping.

Sand is a preventive, not a corrective, measure. Always use sand sparingly. The even starting torque of the diesel-electric locomotive makes use of sand seldom necessary. If sand is necessary, it may be applied as follows:

1. On locomotives equipped with hand sanding, moving the sanding lever to the forward position will apply sand in front of both trucks; and moving the lever to the reverse position will apply sand to the rear of both trucks.
2. On locomotives equipped with electric sanding, closing the sander switch will sand either the front or the rear of both trucks, depending on the position of the reverser.

VI. Electrical Load Limits:

Overheating due to excessive loads can result in serious damage to electrical equipment which may not be apparent immediately but can cause failure

later. Electrical apparatus will safely carry an overload for a limited time if maximum allowable temperature has not been reached. Colored bands on the ammeter indicate allowable overloads.

Operators Should Always Keep Within Proper Load Limits. Overload is permitted only after the equipment has been adequately cooled (either by an idling engine, or by certain non-overload operation as set forth on the plate). When the time limit is reached for any overload, no overload capacity exists at any other amperage above continuous rating. The engine must then be idled to cool the equipment unless the train can continue at full engine speed at or below the continuous rating. The crew should pay careful attention to load limits in any abnormal operation as for example, when a traction motor is cut out, or when motors are overloaded at less than full engine speed (full throttle). The latter condition may exist in humping, or with heavy tonnage upgrade under speed restrictions. Overload capacity is considerably reduced when blowers operate at less than full engine speed.

VII. Inspections During Operation:

A. Check gauges frequently. Investigate and report any great deviation from normal.

1. Lube oil pressure, engine—Normal 50 lb. to 55 lb. when engine is operating at full speed and normal operating temperatures have been reached.
2. Lube oil pressure, turbocharger—Normal 22 lb. to 25 lb. at full engine speed.
3. Fuel oil pressure—Normal 20 to 25 lb.
4. Water temperature—about 150° to 190° F. If engine is too hot, try manual operation described on page 41, or stop engine.
5. Control air pressure—Normal 70 lb.

- B. Rotate the handles on the metal edge lubricating oil strainer two full turns every day. This strainer is located in the radiator compartment.
- C. Check the cooling water level on the gauge at expansion tank every 8 hours. Level must be maintained so that water is visible at all times.
- D. Check the lubricating oil level once every 8 hours. It must be maintained above the "low" mark on the bayonet gauge.
- E. Drain the main air reservoirs once every 8 hours.
- F. Check battery ammeter. It should never show a discharge when engine is running. Report such condition to maintainer. The high charging rate after starting the engine will decrease and approach zero as the battery becomes fully charged.
- G. Make periodic visual inspection of equipment under the locomotive for loose or dragging parts. Report unusual noises or odors to maintainer.

VIII. Cutting Out a Traction Motor:

Should a failure occur in a traction motor, it may be taken out of service by means of a traction motor-cut-out switch in the equipment cabinet. This switch is a multi-pole 4-position rotary switch. The nameplate of the rotary type switch indicates which motors are cut out. To cut out a motor:

- A. Return the throttle and reverse lever to their off positions. Do not turn a cut-out switch under load.
- B. Turn the traction motor cut-out switch to the desired position.
- C. Operate in the usual manner with the remaining motors. It may be necessary to reduce heavy tonnage trains to keep within Load Limits. (Ammeter is in No. 1 motor circuit and will not register if this motor is cut out.)

IX. Stopping the Locomotive:

- A. Retard the throttle to first notch. When load ammeter shows that the current has dropped, the throttle may be moved off. Do not apply brakes under any condition which will cause an overload.

NOTE: If power ever fails to shut off when throttle is retarded, open control switch.

- B. Apply the brakes. Do not use the independent brake to stop a heavy train; use the automatic brake.
- C. If locomotive is to be left standing temporarily, remove the reverse lever and apply the hand brake.

X. Reversing the Locomotive:

The reverse lever determines the position of the large reverser in the equipment cabinet, which in turn controls the direction of travel of the locomotive. Reversing the field circuit in the traction motors changes their direction of rotation.

CAUTION: Never move the reverse lever while the locomotive is still in motion, as this may cause serious damage to the electrical equipment. Do not drift in one direction with the reverse lever set in the opposite direction.

To reverse the locomotive:

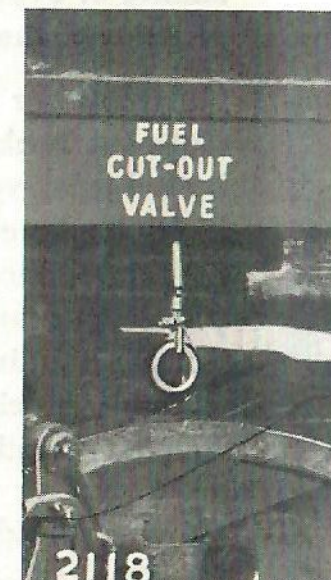
- A. Move throttle off.
- B. Apply brakes to come to full stop.
- C. Change reverse lever to opposite direction.
- D. Release brakes.
- E. Advance throttle slowly.

XI. Stopping the Diesel Engine:**A. Normal procedure:**

1. Let the engine idle ten (10) minutes to dissipate heat.
2. Open the control switch (on control stand).
3. If locomotives are connected in multiple, and it is desired to stop only one engine, set the engine control switch on that unit in accord with its nameplate designations. Opening the control switch on the control stand will stop all engines. Locomotives in multiple may be controlled from the cab of a leading unit which is idled or stopped by the engine control switch.

B. Emergency procedure:

1. In case of fire, collision or other hazard from fuel oil, open the control switch and pull the red emergency fuel cut-off device in the rear corner of the cab, or outside the locomotive under the cab.
2. To start engine after tripping the cut-off valve, check that throttle and reverse lever are off, and manually reset the fuel cut-off valve at the tank.



OUTSIDE FUEL OIL
CUT-OFF PULL RING

FIGURE 7

XII. Shutting Down the Locomotive:

- A. Stop diesel engine in the normal manner, just described.
- B. Open battery switch.

- C. Set the hand brake and release the air brakes.
- D. Remove reverse lever.
- E. Turn off lights.
- F. If locomotive will be exposed to freezing temperature, take necessary precautions as outlined in the section on the Cooling Water System.

XIII. Pusher or Double Heading Service:

In such service, power is controlled on each locomotive in the usual manner, but service brakes are controlled by the leading locomotive only. However, brake pipes can be so set that the non-controlling locomotive can release its own brakes only, to avoid sliding or overheating the wheels. Conform to standard practice of the railroad in your area.

On a pusher locomotive with 6-SL brake equipment, close the brake valve 2-position cutout cock and place both brake valve handles in running position. With 24-RL brake equipment, place the Rotair valve in Pass or Fri position, depending on the service required, place dead-engine cock in live position, and close the double heading cock. Place automatic brake valve in Running position and independent brake valve in Release position.

XIV. Towing Dead Locomotive:

To tow a locomotive dead in a train, the reverse lever should be removed to eliminate any likelihood of connecting the main power circuits, and the brakes should be set to operate like those in the train.

For 6-SL Equipment:

- A. Place double heading cock in "dead" position.
- B. Place both brake valves in Running position and remove handles.

- C. Open charging cock on the dead-engine feature.
- D. If it is desired to keep the maximum braking power below standard, reduce the adjustment of the safety valve on the distributing valve so it opens at 25 pounds.

For 24-RL Equipment:

- A. Close double heading cock.
- B. Place automatic brake valve in Running position and independent brake valve in Release position and remove handles.
- C. Place Rotair valve in Pass position.
- D. Place dead engine cock in Dead position.

XV. Alarms and Protective Devices:

Protective devices are usually connected to the alarm in multiple unit locomotives only. Some equipment (such as train control when installed) has an independent alarm. Dynamic brake alarms are connected to the standard bell, but are described in the braking section. A separate list of operating difficulties gives clues to all troubles, but the following directions concerning the alarm may help locate certain troubles more quickly and definitely.

Ground Relay Closes.

Due to defective high voltage circuit such as insulation breakdown. Sluggish or dirty electrical equipment may cause temporary short circuits. The engine idles and a ground light burns. (On multiple unit equipment, the alarm rings also.)

Remedy.

The grounded condition should be rectified. Some grounds clear themselves. Pressing the ground relay reset button will restore circuits to normal in such instances. If the ground alarm persists after pressing this button, and it is necessary to pull into the clear or operate to a terminal point, open the ground

relay cut-out switch in the cabinet. Don't operate for a prolonged period with this switch open, be governed by local operating rules.

Water Temperature Switch Closes.

Due to hot engine. Indicator light and alarm bell function.

Remedy.

Check cooling system. See separate description.

Engine Shutdown Device Actuated.

Due to low lube oil pressure (see operating difficulties), or to lack of fuel because of an empty tank or tripped safety device.

Remedy.

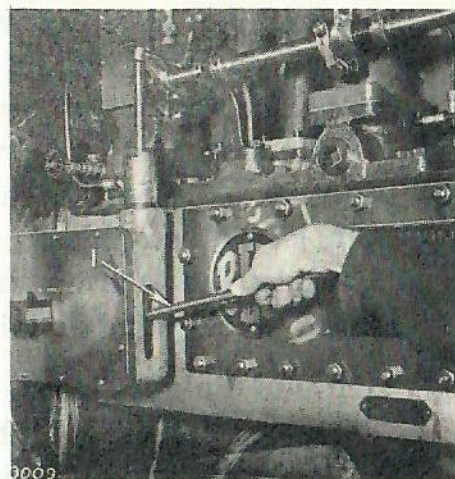
Rectify any faults in the lube oil or fuel oil systems, or reset overspeed stop (see next item).

Engine Overspeed Control.

The engine is prevented from exceeding a specific safe RPM through action of an overspeed stop. This appliance, situated on the front of the camshaft casing at the generator end of the engine, is a spring loaded tripping device, set to trip at a predetermined camshaft

speed. The tripping operation actuates a plunger which moves the fuel control shaft to the no-fuel position and stops the engine. Before starting engine again, the overspeed stop must be reset.

CAUTION: Do not reset until engine has completely stopped.



RESETTING OVERSPEED STOP

FIGURE 8

1. RESET BAR. (Pull down to reset overspeed stop.)

XVI. Miscellaneous Operations:

Some items of equipment in the following operations are special modifications which are installed only when specified by purchaser.

1. Running Through Water.

If necessary to operate through water, keep speed low enough to avoid splashing the motors, and avoid water more than 3 inches above the top of rail.

2. Operating Over Cross-overs.

Reduce throttle at cross-overs to avoid excessive jarring of gears, and electrical pitting of commutators.

3. Rerailing Locomotive.

Do not try to rerail a locomotive under its own power, as serious damage may result to the traction motor from spinning the wheels. However, if only one pair of wheels is derailed it is possible to rerail the locomotive under its own power by cutting out the motor driving the derailed wheels.

4. Dual Control Stands.

Dual control stands are fed through each other to insure that the non-operative stand is neutral. Each control stand is provided with a control switch. The control switch must be closed at the controlling stand, and open at the other stand. The throttle is operative only at the stand where the switch is closed. When changing from one stand to the other, close the second control switch before opening the first control switch. Change-over of reverse lever and brake valve handles, and cutting out the non-operating brake valve is done in routine manner.

5. Overspeed Control.

Check the maximum recommended speed (about 65 miles per hour). When a slightly higher speed is reached, overspeed control initiates a service

application of the air brakes. The diesel engines are automatically idled when such an application occurs. The engineer is first given a whistle warning, and a 6-second delay feature enables him to reduce speed and thus suppress the automatic application.

6. Deadman Pedal.

The deadman foot pedal is a safety device which must be depressed at all times when the locomotive is in operation as a safeguard against the incapacitation or negligence of the operator. A release of the deadman pedal causes a warning whistle to sound for approximately 5 seconds after which the brakes are automatically applied and the engines brought to idling speed. If the deadman pedal is depressed within the warning period, however, no action takes place.

7. Recovery After Penalty, or Emergency, Brake Application.

Following any emergency, speed control, train control, deadman, or similar extra-ordinary brake application, move the throttle to the off position. In many instances, the interlocking is such that traction motors are automatically disconnected to avoid overloading them. However, further interlocking prevents restoration of the electrical circuits until the throttle is in the off position. On 24-RL brake equipment place the automatic brake in Lap position until the brake system recovers.

MULTIPLE UNIT OPERATION

Locomotives equipped for multiple unit operation may be handled as a single locomotive after connections are properly made. In addition to the conventional coupling of locomotives and air lines, the electrical control circuits of the two locomotives must be connected. A jumper for this purpose must be firmly plugged into the receptacles at the end of the locomotives. The controls are then set so that both the power and brakes are controlled from only one cab. The locomotive from which operation is controlled is called the leading unit, and any coupled locomotives are trailing units. Certain alarm and protective circuits, and certain auxiliary controls, such as sanding, are connected through the jumper, but the power plants and heavy duty circuits of the coupled units remain entirely independent of each other. (The M.U. switch is installed only with pneumatic throttle.)

Connecting Units in Multiple (6-SL Equipment):

- A. Couple the units together and connect the air lines and jumpers, making sure that each plug is pushed all the way into the receptacle and locked in place.
- B. Open the cocks at the end of the air lines on both locomotives: main reservoir line, equalizing pipe and brake pipe (throttle line if pneumatic throttle is installed).
- C. On trailing or non-controlling unit:
 1. Place the double heading cock on the brake pedestal in "trailing" position.
 2. Remove the automatic brake valve handle (lap position).
 3. Remove the independent brake valve handle (running position).
 4. Check that the throttle is off.
 5. Put the reverse lever in the "off" position and remove the handle.
 6. Close the multiple unit switch in the equipment cabinet to the "M.U." (Multiple Unit) position.

7. Close the main battery switch in the equipment cabinet.
8. Open control switch.
9. Release the hand brake.

D. On the leading or controlling unit:

1. Make sure the multiple unit switch is closed in the "S" (Single Unit) position.
2. Close main battery switch.
3. Place double heading cock in "lead" position.
4. Close control switch.

E. Start the engines as previously outlined on page 16. It will be necessary to close each fuel pump switch and start the engine in the trailing unit from the trailing cab. However, in the trailing unit, leave the control switch open.

F. The locomotives may now be operated in the same manner as a single unit. The sander foot switch will apply sand to the front or rear of both trucks on both units as determined by the position of the reverser.

Connecting Units in Multiple (24-RL Equipment):

A. Couple the units together and connect the air lines and jumpers, making sure that each plug is pushed all the way into the receptacle and locked in place.

B. Open the cocks at the end of the air lines on both locomotives.

C. On the unit which will be controlling:

1. Make sure that the battery switch, fuel pump switch and control switch are closed, and that the multiple-unit switch is in "S" (single unit) position.
2. Place the Rotair valve in Pass or Frt, depending on the service required.
3. Open the double heading cock.

D. On trailing or non-controlling unit:

1. Close the double heading cock.

2. Place Rotair valve in Pass Lap, or Frt Lap, depending on C-2 above.

3. Put the automatic brake in Running position, and remove handle.

4. Put the independent brake in Release position, and remove handle.

5. Put the throttle in the "idle" position.

6. Put the reverse lever in the "off" position and remove the handle.

7. Move the multiple-unit switch in the equipment cabinet to the "M.U." (multiple unit) position.

8. Check that battery switch and fuel pump switch are closed.

9. Open the control switch.

E. Start the engines as previously outlined on page 16. It will be necessary to start the engine in the trailing unit from the trailing cab. However, in the trailing unit, leave the control switch open.

F. The locomotives may now be operated in the same manner as a single unit. The sander valve will apply sand to the front or rear of both trucks on both units as determined by the position of the reverser.

Procedure for Changing Operating Cab (6-SL Equipment):

A. In the cab which has been controlling:

1. Make at least a 20 pound reduction with automatic brake valve.
2. Place double heading cock in "trailing" position.
3. Remove automatic brake valve handle (lap position), and independent brake valve handle (running position).

B. In the cab which will be controlling:

1. Insert brake valve handles. Move independent brake valve handle to full application position, and automatic brake valve handle to running position.
2. Place double heading cock in "lead" position.

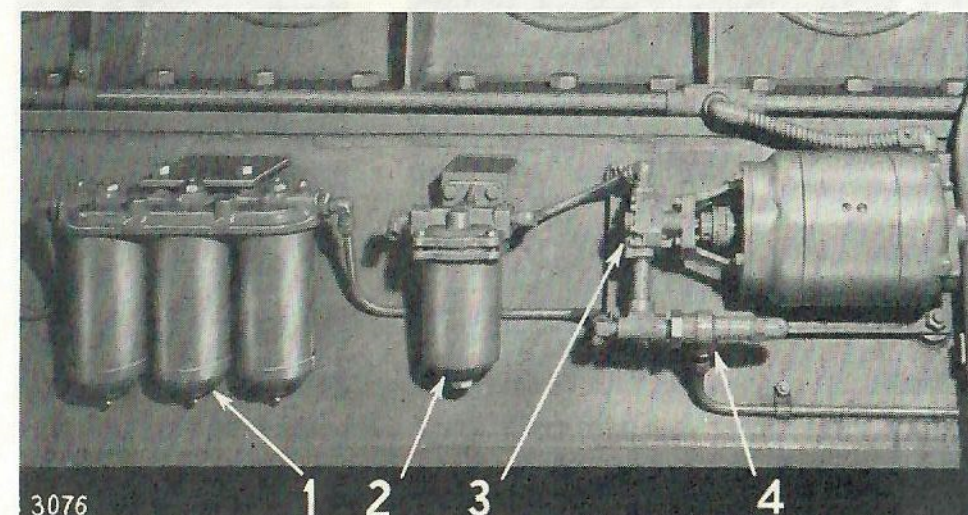
3. Close control switch.
 4. Change multiple unit switch from "M.U." to "S" position.
- C. Return to the former controlling cab:
1. Change multiple unit switch from "S" to "M.U." position.
 2. Open control switch.
- The units are now ready for multiple operation.

Procedure for Changing Operating Cab (24-RL Equipment):

- A. In the cab which has been controlling:
1. Make at least a 20 pound reduction with automatic brake valve.
 2. Move automatic brake valve handle to lap position and independent brake to release position.
 3. Place double heading cock in closed (cut-out) position.
 4. Move K-2-A Rotair valve to Pass Lap, or Frt Lap, as required (or K-2 Rotair valve to Lap position).
 5. Move automatic brake valve handle to running position, and remove both the automatic and independent brake valve handles.
- B. In the cab which will be controlling:
1. Put Rotair valve in Pass or Frt position, as required.
 2. Move independent brake valve to full application position.
 3. Open the double heading cock.
 4. Close control switch.
 5. Change multiple unit switch from "M.U." to "S" position.
- C. Return to the former controlling cab:
1. Change the multiple unit switch from "S" to "M.U." position.
 2. Open control switch.
- The units are now ready for multiple operation.

FUEL OIL SYSTEM

Fuel is supplied to the engine by a motor driven supply pump which draws fuel from the tank through a suction



FUEL OIL SUPPLY PUMP

FIGURE 9

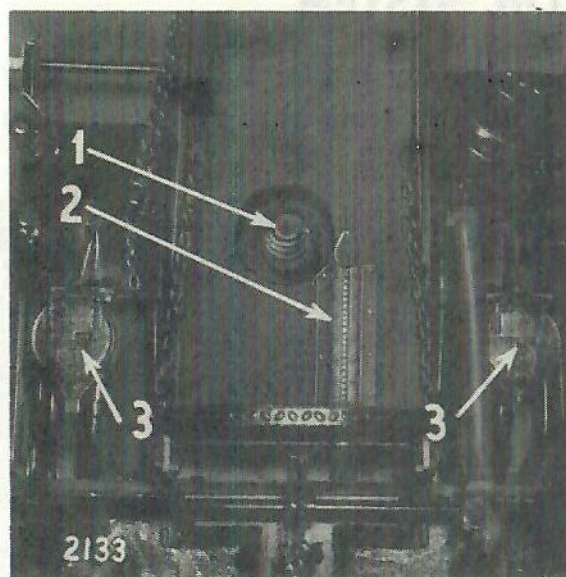
- | | |
|--------------------------|-----------------------------|
| 1. CARTRIDGE-TYPE FILTER | 3. MOTOR DRIVEN SUPPLY PUMP |
| 2. METAL EDGE STRAINER | 4. DISCHARGE RELIEF VALVE |

strainer and forces it through a pressure filter into the fuel oil header, where it supplies the injection pumps. There is a gravity return line from the header to the tank. A pressure relief valve limits fuel pressure in the header to 25 psi, bypassing excess fuel back to the tank. The supply pump is protected against pressure by a relief valve connected to its discharge. The suction strainer and filter cartridges should be cleaned or renewed periodically.

The fuel storage tank, tank filler and gauge are located at the rear of the locomotive. A center tank is added on the AS-616 models. Fill the tank slowly, observing level gauge to avoid overflow.

Governor

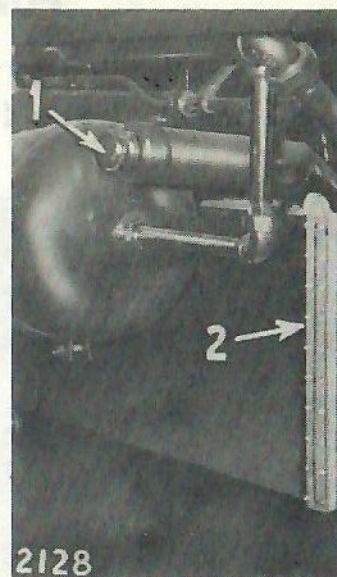
A Woodward PG Governor responds to throttle settings to regulate engine speed, and also engine output,



REAR FUEL TANK and MULTIPLE UNIT
END RECEPTACLES

FIGURE 10

1. FUEL OIL FILL
2. FUEL GAUGE
3. TRAIN-LINE RECEPTACLES
(Multiple Unit)



CENTER FUEL TANK

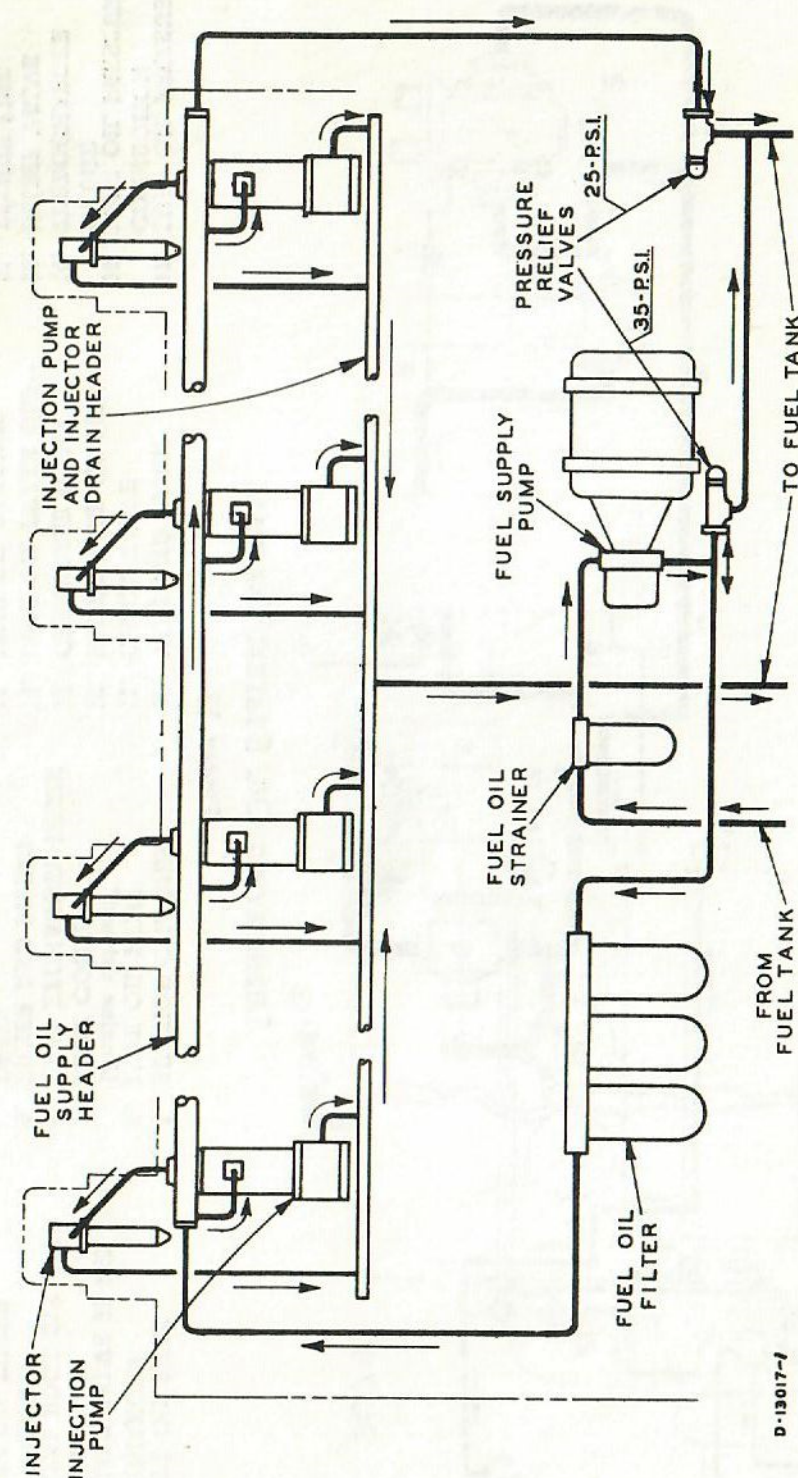
FIGURE 11

1. FUEL OIL FILL
2. FUEL GAUGE

through an added load control device. With an electric throttle, fuel supplied to the engine is regulated by four solenoid valves in the governor which are electrically connected to the throttle. With a pneumatic throttle, the setting is controlled by a pneumatic receiver in the governor which is connected to the throttle system.

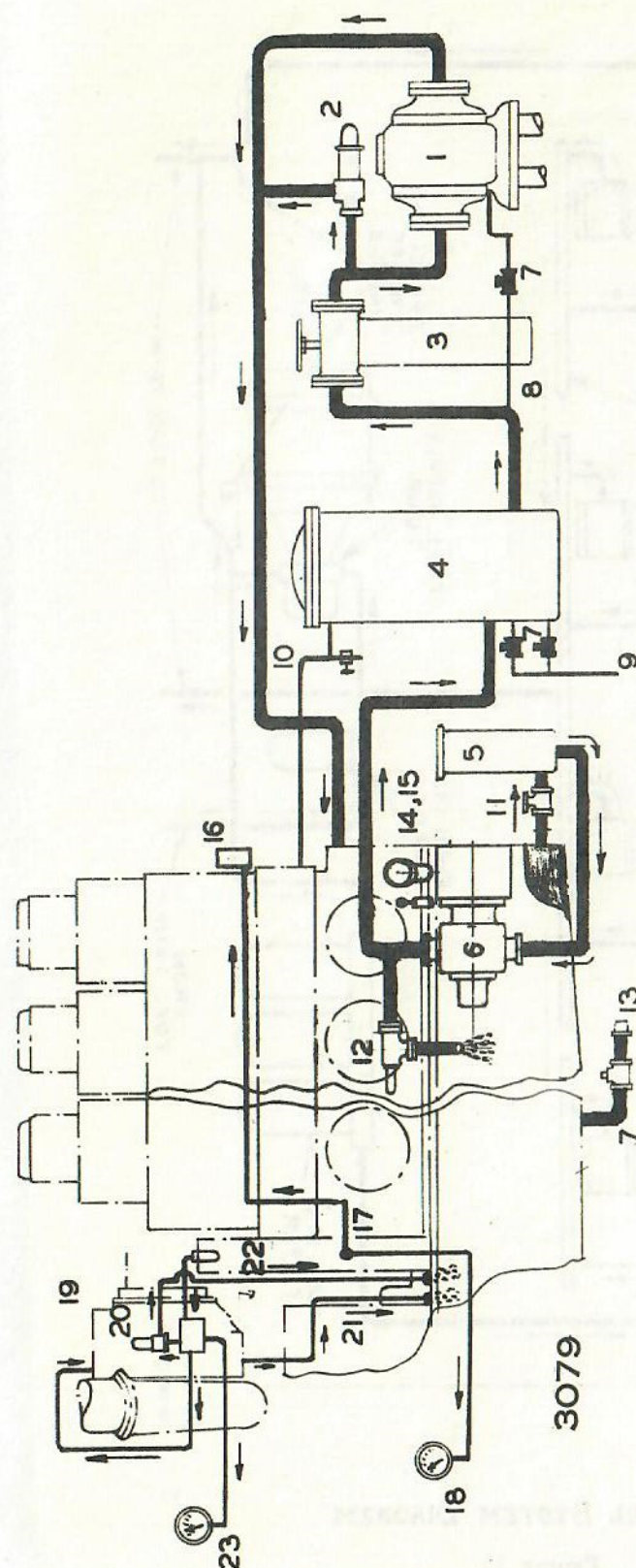
Low Lube Oil Pressure Shutdown Protection

An oil line from the engine lubricating system to the shutdown mechanism in the governor transmits normal engine lube oil pressure to the governor to enable it to function in normal manner. If lube oil pressure is too low, a shutdown piston in the governor operates to move the power piston of the governor to shutdown position, thereby forcing the fuel control shaft to a stop position. A time delay feature permits starting the engine while oil pressure is being initially built up, and a quicker shutdown is provided at high engine speed than at idling speed.



FUEL OIL SYSTEM DIAGRAM

FIGURE 12



LUBRICATING OIL SYSTEM DIAGRAM

FIGURE 13

- | | | | |
|---------------------------------------|-----------------------------------|------------------------------|--|
| 1. LUBE OIL HEAT EXCHANGER | 5. SUCTION STRAINER | 10. VENT AND DRAIN | 17. LUBE OIL PRESSURE CONNECTION |
| 2. RELIEF VALVE 25 PSI (if installed) | 6. LUBE OIL PUMP (Engine driven)* | 11. CHECK VALVE | 18. LUBE OIL PRESSURE GAUGE |
| 3. METAL EDGE STRAINER (if installed) | 7. LOCK COCKS | 12. RELIEF VALVE 125 PSI | 19. TURBOCHARGER |
| 4. LUBE OIL FILTER | 8. HEAT EXCHANGER DRAIN | 13. CRANKCASE DRAIN | 20. RELIEF VALVE |
| | 9. FILTER AND PIPING DRAIN | 14. LUBE OIL FILLER CAP** | 21. RETURN LINE |
| | | 15. LUBE OIL BAYONET GAUGE** | 22. BY-PASS LINE |
| | | 16. LUBE OIL PRESSURE SWITCH | 23. LUBE OIL PRESSURE GAUGE (at Turbo) |

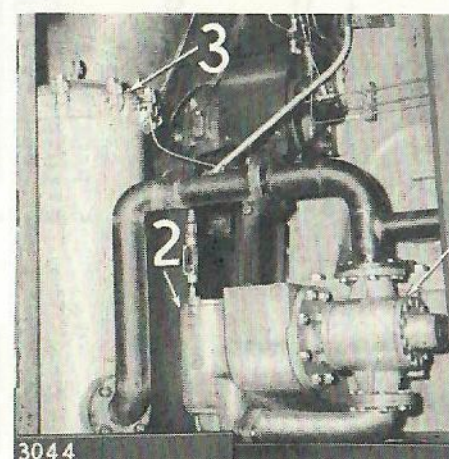
*Located at exhaust side of engine.

**Located on Fuel Pump side of engine.

LUBRICATING OIL SYSTEM

The lubricating oil is drawn from the sump, formed by the bedplate of the engine, through a suction strainer by the engine driven pump. The pump forces the oil through an oil filter, a metal edge type strainer, and a heat exchanger. The oil is then delivered to the engine header, which distributes the oil to all parts of engine requiring lubrication. The pressure gauge in the cab should read between 50 lb. and 55 lb. (This is equivalent to 65 lb. at the header.) Should pressure become excessive, a relief valve will spill the pump output back to the engine base. The water connections of the heat exchanger are shown in the Cooling System Diagram.

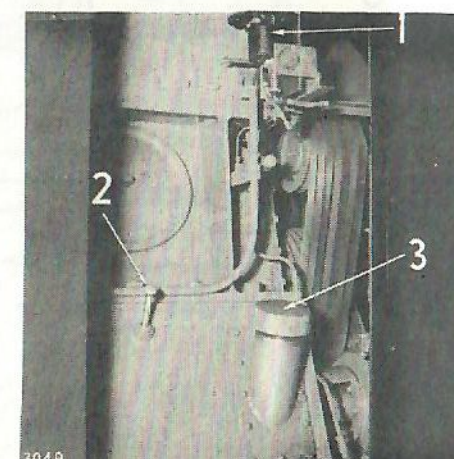
The oil level in the sump should be checked daily and must be maintained above the "low" mark. To fill the crankcase, pour the proper type of oil through the filler pipe. Fill to the "full" mark on the bayonet gauge. To drain oil from the engine, open the drain valve and remove the plugs from the bottom of the camshaft trough. Also, be sure to drain the strainers, the filter and the heat exchanger, when changing crankcase oil.



LUBE OIL PUMP AND STRAINER

FIGURE 14

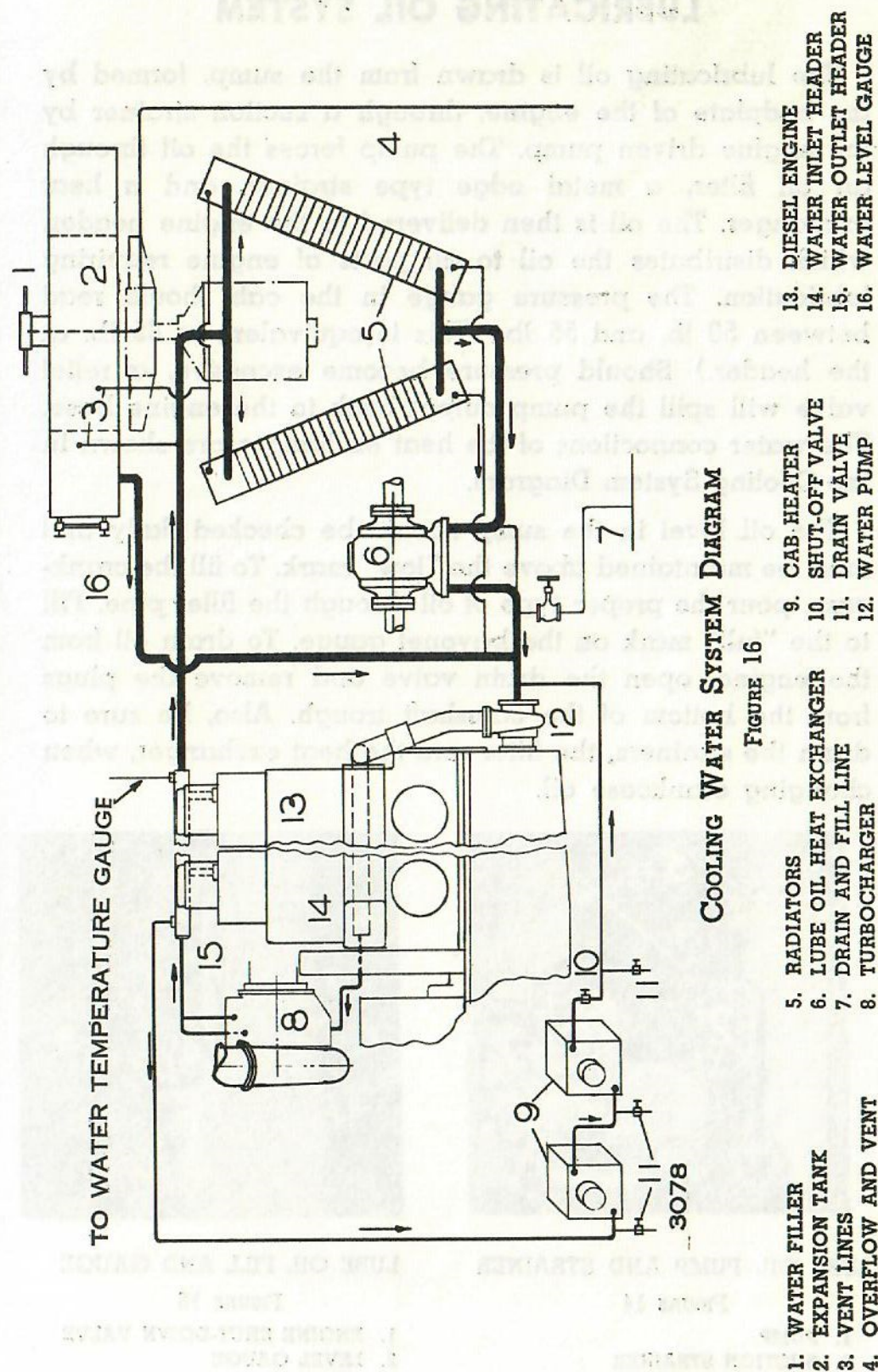
1. PUMP
2. SUCTION STRAINER
3. FULL FLOW FILTER



LUBE OIL FILL AND GAUGE

FIGURE 15

1. ENGINE SHUT-DOWN VALVE
2. LEVEL GAUGE
3. FILL



COOLING WATER SYSTEM

Water is circulated through the engine, heat exchanger and cooling radiator by an engine driven pump. An expansion tank vented to the atmosphere through an overflow pipe acts as a reservoir for maintaining a full system. The water level in the expansion tank must be maintained above the bottom of the gauge. This gauge is on the radiator compartment bulkhead above the temperature control equipment at the front of the engine compartment. If leaks are suspected, the crew should endeavor to locate them while engine is warm, and report to maintainer. However, the packing gland of the water pump is adjusted to leak about 3 or 4 drops per minute normally.

To fill the system, add water through the connection located over No. 1 truck on right side of the locomotive. The system can be filled through the filler on the roof near the front, but it is not recommended because of the danger of trapping air in the system. If the engine overheats because of low water level, idle the engine and add hot water if possible. If it is necessary to use cold water, it should be added very slowly.

Drainage

If the locomotive is to be left standing exposed to freezing temperature, it will be necessary to drain the cooling system or use an outside source of steam to prevent freezing. If a steam source is available, connect it to the drain pipe through a check valve so that the water can not back up into the steam line. Open the drain valve enough to allow steam to enter the system. To drain the system, open the drain valve (Figure 16). Also drain the heat exchanger, the cab heaters, and the turbo-charger cooling system. Condensed water may accumulate in the turbine casing which has a separate drain valve.

Fan Control Switch

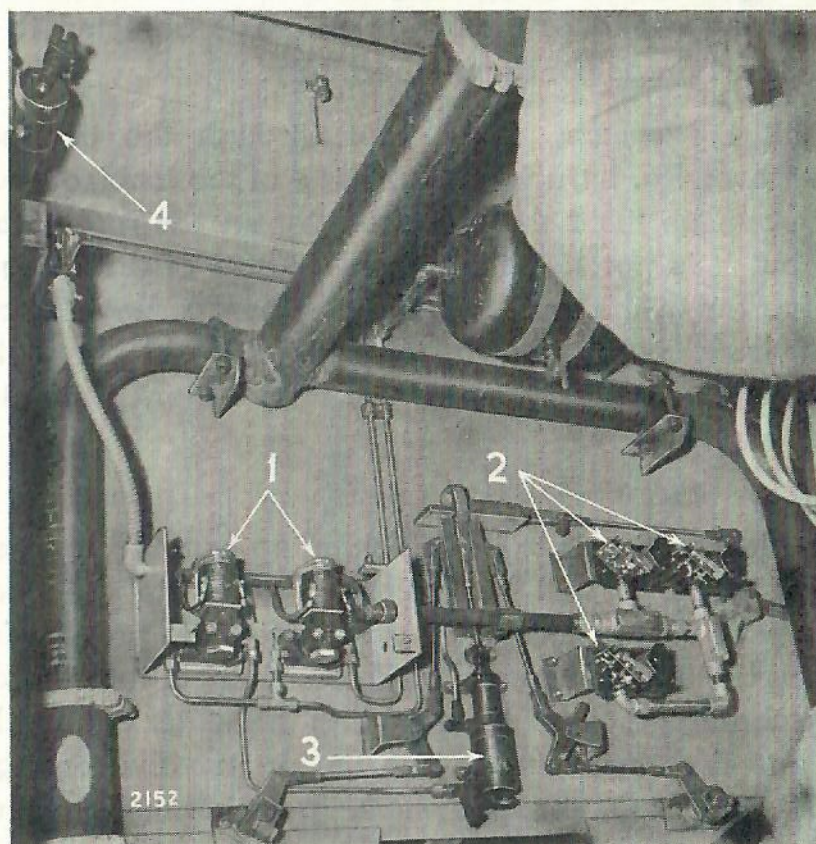
The fan control switch is a small double-pole double-throw manually operated switch in the electrical equipment

cabinet. It has three positions. The fan contactors are connected as follows:

Off Position—Fans will not operate.

Automatic Position—Fan speed is automatically regulated.

On Position—Fans operate at intermediate speed if automatic temperature control fails. Shutters are provided with dynamic braking to determine the path, but not volume, of air flow. They are not part of the water temperature controls.



TYPICAL EQUIPMENT ON RADIATOR BULKHEAD

Dynamically Braked Locomotives

FIGURE 17

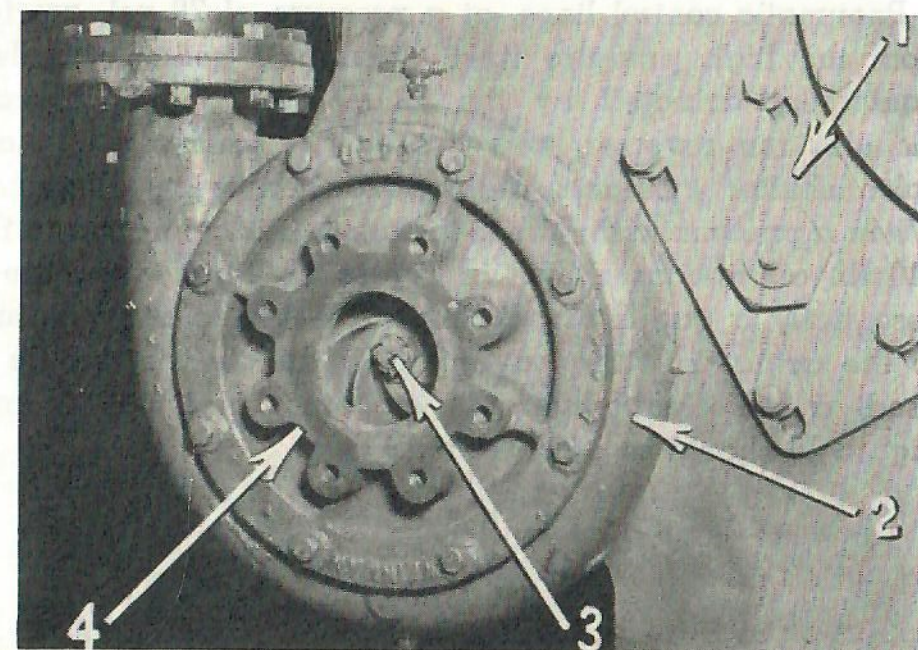
1. SHUTTER MAGNET VALVES
2. SHUTTER LIMIT SWITCHES
3. SHUTTER OPERATING CYLINDER (for lower flaps)
4. SHUTTER OPERATING CYLINDER (for top side shutters)

Automatic Temperature Control

When the fan switch is in "auto" position, radiator fans are driven by electric motors whose speed is varied by thermostatic control of the fan motor contactors. When water temperature rises moderately, a fan contactor closes which operates fans at low voltage. A further rise in temperature closes a contactor which connects full generator voltage to fans, thereby increasing their speed. Further increase in temperature closes a contactor which shunts the fan motor fields for still faster operation. As the water cools, the fan speed automatically decreases.

Manual Control

When the automatic system does not function properly, check fan motor breaker if fans are not running. Non-automatic cooling may be had by moving the 3-position fan switch to the "on" position. The fans will run at inter-



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WATER PUMP AND IDLER BRACKET

FIGURE 18

- | | |
|-----------------------------------|------------------------------------|
| 1. CHAIN IDLER ADJUSTMENT BRACKET | 3. IMPELLER NUT (Left Hand Thread) |
| 2. PUMP CASING | 4. PUMP SUCTION HEAD |

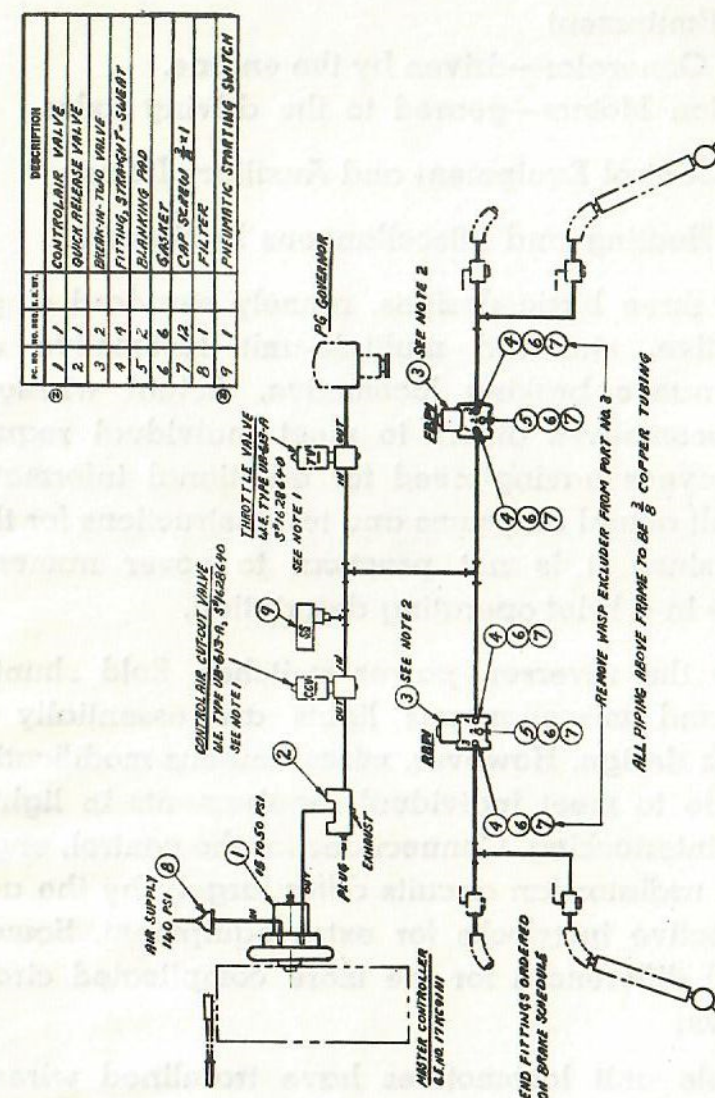
mediate speed. If the temperature gauge indicates excessive cooling, set fan switch to "off" position briefly, or shift from "on" to "off" as required.

Hot Water Switch

An automatic hot water temperature switch (if installed) rings the alarm and lights an indicator light when it trips. (It may be connected, as a modification with pneumatic throttles, to idle the engine through a throttle valve.) Operators of single-unit locomotives should watch their temperature gauge, but the switch is normally supplied on multiple unit locomotives to give adequate protection for trailing units. It will, of course, function in any leading unit so equipped.

PNEUMATIC CONTROLS

Pneumatic control lines, at a pressure of 70 psi, are fed from the high pressure lines through a reducing valve. Equipment actuated by the 70 pound control pressure includes the reverser, power switches, sanders and horn (also shutter cylinders on dynamic brake installations). When a pneumatic throttle is installed, it is connected to the 140 lb. air line as shown in Figure 19. Such a throttle is essentially a variable reducing valve controlling pressure to the actuator in the governor. (If an electric throttle is used, a PG electro-hydraulic governor is installed, and Figure 19 should be disregarded.)



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TYPICAL PNEUMATIC THROTTLE CONTROL SYSTEM

FIGURE 19

ELECTRICAL SYSTEM

INTRODUCTION

The electrical equipment of the locomotive may be considered in the three following main groups:

1. Power Equipment

Main Generator—driven by the engine.

Traction Motors—geared to the driving axles.

2. Power Control Equipment and Auxiliary Items.

3. Lights, Heating and Miscellaneous Equipment.

There are three basic designs, namely standard single-unit locomotive, standard multiple-unit locomotive and standard dynamic braking locomotive. Actual wiring of individual locomotives differs to meet individual requirements. Employees having need for additional information should consult actual diagrams and test instructions for their locomotive, since it is not practical to cover numerous modifications in a brief operating description.

Circuits to the reverser, power switches, field shunting contactors, and miscellaneous lights are essentially the same in each design. However, miscellaneous modifications may be made to meet individual requirements in lighting circuits and interlocking. Connections for the control, engine starting and radiator fan circuits differ largely by the addition of protective interlocks for extra equipment. Some of the principal differences for the more complicated circuits are as follows:

(1) Multiple unit locomotives have trainlined wires in the control, sanding, alarm and compressor circuits. Interlocks in the control circuits render all but one of the control stands inoperative.

(2) Dynamic braking circuits require the addition of dissipating resistors in the main power circuits, plus a few contactors for separating the traction motor fields from their armatures during braking. Motor connections in power

operation are the same on dynamically braked locomotives as on standard locomotives of the same type. Changes in the control circuits and auxiliary circuits require more detailed description later.

(3) On locomotives of less than 1600 h.p., field excitation circuits differ, and fan motor circuits are eliminated because fans are mechanically driven.

POWER CIRCUIT

The main generator supplies power to the traction motors over two or four parallel circuits. Each of these circuits contains two traction motors on 4-motor locomotives, (or 3 motors in series on 6-motor locomotives), initially, plus a reverser, and power switches. Transition establishes four parallel circuits at higher speeds.

Traction motors are connected to the power supply only when the power-switches close (automatically) after advancing the throttle. Transition of motor connections between series and series parallel occurs automatically through the operating range of the locomotive.

Fan motors, on electrically operated cooling systems, are connected to the power supply only when the fan breaker is closed and the proper fan contactors are closed by a thermostatic controller.

The coil of the wheel slip relays, ground relay, and traction motor field shunting relays are connected to, and actuated by, the high voltage power circuit, but their contacts are connected in the control circuit.

The starting contactors are open except during starting. The various field contactors, the battery contactor and the auxiliary generator power breaker and field breaker must close during normal operation. Other details in this portion of the circuit are largely internal to the voltage regulator, load regulator, etc., which require special instruction and equipment before working thereon, and are of little concern to employees outside the maintenance department.

CONTROL CIRCUITS

Relays

A relay is a coil which opens or closes a set of comparatively light-duty contacts (generally in a controlling circuit). The coil may be in either the high or low voltage circuit and may be adjusted to pick-up or drop-out at various voltages, and calibrated to respond to varying operating conditions. As the name implies, it relays an impulse to other equipment (mostly contactors), and more than one contactor may be controlled by a single relay.

Contactors

A contactor is a coil-operated set of contacts (generally heavy-duty, and in the circuit being controlled). Its closed or open positions generally depend on whether it is energized or de-energized. There is usually no adjustment for intermediate voltages or currents, because the more sensitive relays are used for such purposes. Light-duty contacts on a contactor are called interlocks which are described in the next paragraph.

Interlocks

An interlock is an auxiliary switch mounted on, and controlled by, another switch, contactor, valve or similar control equipment. It is operated by a cam or mechanical linkage which is so connected that the opening and closing of the auxiliary circuit is dependent on the operation of equipment in the main circuit. They are used to control the sequence of operation, or to permit making or breaking related circuits only when proper conditions exist. The chief concern to the operator is that sluggish or faulty interlocking can cause faulty locomotive operation.

Electro-pneumatic Valve

An electro-pneumatic valve (or magnet valve) consists of an electrical coil in a controlling circuit which controls valves for the pneumatic operation of certain equipment. For example the reverser and the power switches are

pneumatically operated by a valve which is built into the equipment. Control air pressure is maintained from the main air reservoir, but at a lower pressure.

Voltage Regulator and Battery Protection

A voltage regulator holds the auxiliary generator voltage constant over the normal speed range of the diesel engine. It is set slightly above battery voltage so the battery will receive a charge if necessary. A reverse current relay protects the battery against discharge through an idle or defective auxiliary generator. The relay opens a contactor in the circuits whenever a reverse current flows. This contactor closes automatically any time auxiliary generator voltage exceeds battery voltage. Operators should not change the adjustment or setting of this equipment.

Wiring Diagrams

One means of understanding electrical circuits is to trace the energized (or "hot") wire. A brief description of the operating sequence follows:

1. With the battery switch open, the only active circuits are certain lights fed directly from the battery through their individual switches.
2. Closing the battery switch makes power available to all other lighting circuits and to the control circuit. The effect of closing a light switch should be obvious from its nameplate, except for the headlight. The 3-position headlight dimming switch is not a circuit breaker, and protection for this circuit is provided by the lighting breaker in the equipment cabinet which must be closed to supply the headlight with current.
3. Closing the control switch and fuel pump switch brings power to the fuel pump circuit and starting circuit.
4. Pushing the start button, with the engine control switch properly set, energizes the cranking contactors, which

connect the battery to the generator which then turns as a motor to crank the engine.

5. Advancing the throttle, with reverse lever set, closes a power control contactor, which energizes power switches, first in series motor connection, then through a transition relay for series-parallel connection.

Lighting Circuit

The cab light and cabinet light are the only ones directly connected to the battery, all others being connected through the battery switch. The heaters and headlights are fed through a circuit breaker in addition to their separate switches or rheostats. Nameplates identify the other lighting circuits. The speed recorder and nameplate lights are fed through the gauge light switch. The nameplate also has an independent switch and dimmer.

OPERATING DIFFICULTIES AND CAUSES

(*Denotes items usually in multiple unit equipment only.)

- I. **Engine Does Not Turn When Starting Button Is Pressed**
 - A. Battery switch open; fuel pump switch open.
 - B. Control switch open (except M.U. locomotives).
 - C. Engine control switch in wrong position.*
 - D. Multiple unit switch in wrong position.*
- II. **Engine Turns But Does Not Fire, or Does Not Continue Running After Releasing the Starting Button**
 - A. Fuel tank empty.
 - B. Emergency fuel cut-out valve is tripped. Reset.
 - C. Overspeed stop has been tripped. Reset.
 - D. Low fuel oil pressure.
 - E. Insufficient oil supply in the governor.
- III. **Engine Does Not Respond to Throttle Setting**
 - A. Low control air pressure.
 1. Low main reservoir air pressure.
 2. Control air cut-out cock closed.
 3. Control air pressure reducing valve sticking. Try tapping it.
 - B. Governor linkage disconnected.
 - C. Ground relay closed.
- IV. **Locomotive Does Not Move**
 - A. Reverser not in the forward or reverse position.
 - B. Control Breaker open.
 - C. All traction motors cut-out. (Check cut-out switch.)
 - D. Hand brake still set.
 - E. Starting contactors stuck in closed position.
- V. **Engine Stops**
 - A. Overspeed stop has tripped. Reset (Fig. 8). Notify maintainer if it continues to trip.
 - B. Low lubricating oil pressure, causing the engine shutdown device to operate.
 - C. Emergency fuel cut-out valve has been tripped. Reset.

- D. Fuel tank empty.
- E. Engine control switch in wrong position.*

VI. Low Fuel Oil Pressure

- A. Fuel tank empty.
- B. Emergency fuel cut-out valve tripped. Reset.
- C. Sticking relief valves. Try tapping them.
- D. Faulty pump.

VII. Low Lubricating Oil Pressure

- A. Low oil level.
- B. Clogged pressure strainer. Turn the handle on top of the strainer two revolutions in the clockwise direction.
- C. Sticking relief valves. Try tapping them.
- D. Hot or diluted oil.
- E. Faulty pump or leaking lines.
- F. Clogged heat exchanger.

VIII. Engine Overheats

- A. Low water level.
- B. Faulty radiator shutter control.
- C. Radiator fans not functioning properly. (See page 41.)
- D. Water pump not functioning properly.

IX. Air Pressure Too High or Too Low

- A. Compressor governor cut-out cock closed.
- B. Compressor governor sticking. Try tapping it.

X. Battery Ammeter Shows Discharge (Engine Running)

- A. Auxiliary Generator Field Switch open.
- B. Auxiliary Generator Power Switch open.
- C. Poor contacts on battery contactor or reverse current relay, or voltage regulator.

NOTE: Always notify maintainer when any operating difficulty is experienced, even if the trouble has been corrected by the above suggestions.

DYNAMIC BRAKING WITH PNEUMATIC THROTTLE

GENERAL DESCRIPTION

Locomotives are sometimes equipped with a dynamic braking system in addition to the standard air braking equipment. Dynamic braking is controlled entirely by the throttle and reverse lever. The energy involved in retarding the train by dynamic brakes is dissipated in the electrical equipment instead of in the brake shoes. At such times, the traction motors act as generators driven by the locomotive. This reduces wear and tear on brake shoes and, on long descending grades, eliminates delays which may otherwise be necessary for cooling wheels and shoes. Applications of the automatic brakes on the cars of a train are possible at all times, regardless of the setting of dynamic braking controls. However, the air system is interlocked with the electrical circuits so that it is impossible to make an automatic application of brakes on the locomotive during dynamic braking. Emergency applications may be made by the automatic brake at any time (although in some cases, a power knock-out device must first automatically interrupt the dynamic braking circuits).

OPERATION

Dynamic braking will not function unless the dynamic braking cut-out switch is in dynamic braking position (closed), and it is generally left in that position. If there is no dynamic braking cut-out switch, it is incorporated in a fan relay cut-out switch. A separate set of electrically driven fans cools the braking resistors. They operate automatically, but if the circuit is defective the braking circuits are automatically kept inoperative. The usual braking procedure may be summarized as follows:

1. Reduce throttle to "off". Wait about 10 seconds before setting controls for dynamic braking.
2. Move reverse lever to dynamic braking position. If there is more than one such position, use the one cor-

responding to the direction of travel. (Trip a small latch under the lever if necessary to release it.)

3. Place the throttle in the first notch until an ammeter reading is obtained, then advance gradually until the desired amount of dynamic braking is obtained, but keep the ammeter within the normal operating range. A dynamic braking overload light will give indication when braking current becomes excessive. The throttle should be retarded sufficiently to extinguish the light.
4. If additional braking effort is needed, the usual automatic air application may be made simultaneously. (If the dynamic brakes do not function at all, the air brakes alone can be used in the usual manner.)
5. To resume normal operation, first move the throttle to "off", next move the reverse lever to the position corresponding to the direction of travel, then use the air brakes or throttle with due regard to the conditions set forth in the following important paragraph.

NOTE: Dynamic braking differs greatly from air braking and therefore requires special attention by the operator in order to handle the train smoothly. The feel of the train is best obtained only from experience, but the principal fact to remember is that the train is bunched in dynamic braking. At very low speeds, the dynamic braking effort fades out and air brakes must be used to come to a complete stop. Whenever dynamic braking ceases, either because of the low-speed fade out, or because the engineer no longer desires to brake, be careful to avoid a quick run-out of the head end which may have sufficient force to damage drawbars.

Dynamic braking is not effective above certain maximum speeds. Check what that speed is for your

locomotive (as posted in the cab), and if braking is needed at high speed, use the air brakes until the speed falls within the dynamic braking range.

SUPPLEMENTARY INFORMATION

The following miscellaneous information may be useful to operating personnel at times, especially if they must investigate some irregularity in operation.

The changes in electrical connections are controlled by a system of relays which function automatically when the foregoing manual controls are operated. The action is mainly as follows:

1. The traction motor fields are disconnected from their armatures. The armatures are connected to dissipating resistors, and the fields alone are connected to the generator.
2. The fans which cool the braking resistors are automatically connected to the traction motor armatures. A fan relay prevents complete changeover to dynamic braking circuits if these fans don't operate properly.
3. After braking circuits are established, advancing the throttle increases the braking effort by acting on both engine speed and generator field strength. Increasing either, or both, of these variables will increase the generator output to the traction motor fields. As traction motor field strength is increased, dynamic braking effort is increased.
4. The locomotive wheels would frequently slide if subjected to both dynamic braking and air braking at the same time. A brake interlocking valve functions automatically to prevent simultaneous application of dynamic brakes and automatic air brakes on the locomotive.

5. Other protective devices may be installed according to individual specifications. If an alarm is connected to indicate operating failure in the fans on the dissipating resistors, avoid dynamic braking until the trouble is rectified. Do not use the dynamic brakes if the wheel slip buzzer sounds continuously, but intermittent sounding may be disregarded.
6. If throttle has been advanced too soon during change-over into or out of braking, it may be necessary to again return it to its off position momentarily to clear all protective interlocking devices.

If there is no dynamic braking effort:

1. Check that the dynamic braking cut-out switch or fan relay cut-out switch, depending on the installation, is in the correct position.
2. Check that the traction motor cut-out switch is in correct position.
3. Check braking-resistor fans, breaker or relay.

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